RESEARCH NOTE 80-12

LEVEL II

1

ANALYSIS OF INFORMATION FLOW IN THE TACTICAL OPERATIONS SYSTEM

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes the results of an analysis of the Tactical Operations System (TOS), communications subsystem ~~performed in the second phase of a project~~ to develop infomation management concepts and procedures for automated battlefield command and control systems. The research effort evolved from previous work to develop a design/decision aid (DDA) for the evaluation of alternative information management policies. The original DDA model was concerned exclusively with the Division

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Abstract (continued)

Computing Center. The original effort was expanded to encompass both the distributed processors -- the Tactical Computer Systems and Tactical Computer Terminals -- and the supporting communications. The resulting model not only provides a tool for the analysis of TOS and its component parts, but also has the potential for application to other distributed command support systems with a central node and data base.

PREFACE

This document is one of eight reports which describe the work performed by Vector Research, Incorporated (VRI) and its subcontractor, Perceptronics, Incorporated, for the US Army Research Institute for the Behavioral and Social Sciences (ARI) under the second phase of contract number DAHC19-78-C-0027. The work described was performed over 12 months of an anticipated 36-month three-phased project. The overall objective of the project has been to produce procedural guidelines to be used by divisions in the field in developing standard operating procedures for information management in the Tactical Operations System (TOS). As a consequence of the redirection of the TOS development effort in November 1979, the objective of this work was reinterpreted to include automated battlefield command control systems (ABCCS) in general, using TOS for an explicit example of the design, human factors, and management control considerations which must be addressed.

The VRI study team for phase II was comprised of Dr. Robert W. Blum (Project Leader), Ms. Cathleen A. Callahan, Dr. W. Peter Cherry, Mr. Mark G. Graulich, Mr. Donald Kleist, Mr. Mark Meerschaert, Mr. Gregory Touma, and Mr. Gary Witus. The Perceptronics team for phase II consisted of Dr. Michael G. Samet and Dr. Ralph E. Geiselman.

The authors wish to acknowledge the helpful contributions of Dr. Stanley M. Halpin and Mr. Robert Andrews, who were charged with monitoring the study for ARI; and LTC L. Walker, MAJ. A. Edmonds, and Mr. M. Carrio, who performed a similar function for that portion of the study effort which was jointly sponsored with ARI by the US Army Communications Research and Development Command (CORADCOM).

The eight reports are as follows:

Blum et al., **Information Management for an Automated Battlefield Command and Control System: Executive Summary**, ARI Research Report 1249 -- presents an overview of the project and the other seven reports.

Callahan et al., **Guidelines for Managing the Flow of Information in an Automated Battlefield Command and Control System**, ARI Research Report 1248 -- describes considerations in and procedures for the management of contemporary ABCC systems.

Geiselman and Samet, **Guideline Development for Summarization of Tactical Data**, ARI Technical Report 458 -- an analysis of procedures for the extraction, summarization, and presentation of critical information.

Witus et al., **Analysis of Information Flow in the Tactical Operations System (TOS)**, ARI Research Notes 80-12 -- describes the purpose, approach, and results of a TOS analysis which focused on TOS when integrated with a planned communications support system.

Witus et al., **Description of the Tactical Operations System Information Flow Model**, ARI Research Notes 80-13 -- describes the representation of TOS used to develop the analysis package and the mathematics of the model.

Witus et al., **User's Manual for the Tactical Operations System Analysis Package**, ARI Research Notes 80-14 -- explains the use and operation of the analysis package.

Witus et al., **Programmer's Manual for the Tactical Operations System Analysis Package**, ARI Research Notes 80-15 -- describes the programming details of the package to facilitate modifications or transfer between host systems.

Cherry, WP, **All Source Analysis System: Design Issues**, ARI Working Paper HF80-XX -- a discussion of design issues associated with the emerging ASAS concept.

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EXHIBITS

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1.0 INTRODUCTION

This report describes the results of an analysis of the Tactical Operations System (TOS) communications subsystem performed for the Army Research Institute for the Behavioral and Social Sciences. The research effort evolved from previous work to develop a design/decision aid (DDA) for the evaluation of alternative information management policies.[1] The original DDA model was concerned exclusively with the Division Computing Center. The original effort was expanded to encompass both the distributed processors -- the Tactical Computer Systems and Tactical Computer Terminals -- and the supporting communications. The resulting model not only provides a tool for the analysis of TOS and its component parts, but also has the potential for application to other distributed command support systems with a central node and data base.

The report is organized into seven chapters and supplemented by two appendices. Chapter 1.0, Introduction, presents a brief background description of TOS, discusses the purpose and scope of the analysis, and presents a synopsis of the analysis results. Chapter 2.0, Critical Components, develops a baseline -- a reference point for subsequent analysis -- and uses the baseline to identify the critical system components. Chapter 3.0, Operating Guidelines, develops a guideline for safe system operation based on the control procedures of the provisional Standard Operating Procedures and an analysis of the behavior of system components when stressed. Chapter 4.0, Impacts of Field Conditions, discusses the impacts of transmission bit errors, voice competition, and

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[1]See Information Management for the Tactical Operations System (TOS), ARI Research Report 1228, October 1979.

the use of retransmission stations on communications net capacity. Chapter 5.0, Opportunities for Improvements, discusses the opportunities for system improvement resulting from various hardware and software changes. Chapter 6.0, Method for Selecting Design Changes, discusses strategy considerations in selecting from a menu of possible design changes. Chapter 7.0, Human Factors, examines the automatic system demands for human intervention. Appendix A, Baseline Definition, lists the inputs defining the baseline case to the model of TOS used in the analysis.[1] Appendix B, Computer Program Inputs and Outputs, is a printout of the baseline case inputs and outputs from the computer program implementation of the TOS Model.[2] Appendix C is a glossary of acronyms.

1.1 BACKGROUND

The A-Specs provide a general description of TOS:

"The TOS is intended to be a secure, automatic data processing system serving the command and staff elements of the Division at the Tactical Operations Center (TOC), Tactical Command Post (TAC CP), subordinate Brig[illegible] Command Post (BDE CP), subordinate Battalion Command Post (BN CP), a subordinate Armored Cavalry Squadron and support liaison points. The system would provide the capability to aid the commanders in controlling and processing, storing, retrieving and disseminating information concerning the status and location of friendly and enemy units. The TOS

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[1]Documented in ARI Research Notes 80-13.

[2]The programs are documented in ARI Research Notes 80-14 and 80-15.

would be secure, modular, and would provide for commonality and interchangeability of hardware components among its functional areas and with other Army tactical systems. In non-tactical deployment, the system would have the capability to permit training of user personnel without affecting its mission-ready capability.

"The primary mission of TOS would be to provide the commander and his staff, in a timely manner, the operations and intelligence information that they require to: see the battlefield; make decisions to exploit enemy force weaknesses; and, determine courses of action for the effective employment of friendly resources. As a command and control system, TOS would have a secondary mission to function as the focal point for the exchange of data with other tactical data systems.

"The TOS would operate in a mid to high intensity Warfare environment. The critical formidable threat is expected to be highly mobile, numerically superior, armored and mechanized forces. The critical technical threat to TOS is expected to be electronic warfare (EW) operations oriented toward analyzing the system and its communications with the intent of determining information content or degrading the TOS communications or the operation of the system itself. TOS would counter the critical formidable threat by providing the Division Commander and his staff near real-time information concerning the tactical situation. TOS would counter the critical technical threat by techniques which nullify or resist the threat."[1]

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[1] System Specifications for the Division Tactical Operations System (DTOS), CO-SS-3000-TO, April 1979.

1.2 PURPOSE AND SCOPE

The purpose of the present effort was to examine the capability of the communications subsystem to support TOS and to examine the impacts of selected field conditions and design alterations on that capability. The first stage of the analysis was to examine the communications subsystem as described in the A and B level specifications. The field conditions and design alternatives to be examined were selected by the sponsor. The analysis methodology and results, although specific to TOS, are capable of generalization to other communications systems.

Several important considerations impacted on the analysis. First and foremost, the analysis was to focus on system characteristics, not engineering characteristics. Parameter values describing the engineering characteristics would be inputs to the analysis. An engineering analysis of the components, although undeniably important, was beyond the scope of this analysis. Other restrictions of the scope were: (1) to consider only hardware and software delays and congestion, excluding human factors; (2) to examine the steady state performance of a static system, as opposed to the transient behavior of a network whose users were in motion and would alter their communication patterns; and (3) to disregard memory requirements and limitations due to finite memory resources. Within this scope and the further limitations of time and available data, the analysis addresses a broad range of topics relevant to communications support for a tactical data system.

1.3 SYNOPSIS OF ANALYSIS RESULTS

This section summarizes the analysis results. The model used for the analysis represents TOS in a variety of situations. FM nets are

found to be the most critical components in each situation examined. Voice competition and the use of retransmission stations could reduce the capacity of the FM nets below the level needed to support projected peak hour loads. Opportunities exist for increasing capacity and could result in significant gains. However, an intelligently constructed strategy for selecting design changes must be employed. Finally, a consideration of human factors indicates a significant possibility that the level of user intervention required to keep the system operating is too high.

1.3.1 CRITICAL COMPONENTS

The goal of chapter 2.0 is to identify the critical components of the TOS communications subsystem. A component is considered critical if it is busy most of the time or causes long delays of messages in transit. A baseline case is constructed based on TOS specifications. Benchmark analysis is performed on the baseline case, producing results concerning expected delay and utilization at each component. FM nets are identified as the critical components.

1.3.2 OPERATING GUIDELINES

Chapter 3.0 develops a basic indicator of the level of user demand which a component can safely support. The impact of traffic rate on average delays and average queue lengths is examined. Evidence is provided that a maximum utilization of 80 percent, achieved by controlling traffic rate, is a reasonable operating guideline. Component capacity is defined as the traffic rate which causes 80 percent utilization.

1.3.3 IMPACTS OF FIELD CONDITIONS

Chapter 4.0 examines the effects of field conditions on communications net capacity. The effects of error rate, voice competition, and the use of retransmission stations are studied. Graphs of capacity as a function of error rate are shown for an example FM net, the CAV SQN. Field conditions can degrade TOS performance significantly. There are field conditions in which FM nets will not be able to sustain the peak hour message loads as given in the Traffic Projection Analysis.[1]

1.3.4 OPPORTUNITIES FOR IMPROVEMENT

The goal of chapter 5.0 is to investigate the potential for increasing communications net capacity, especially that of the FM nets. The effects of transmission rate, EDC procedures, and message length are studied. Considerable potential is demonstrated for increasing communications net capacity by a variety of methods.

1.3.5 A METHOD FOR SELECTING DESIGN CHANGES

Chapter 6.0 is a discussion of some of the factors involved in the strategy of choosing design changes. Cost considerations are excluded. A general approach is presented and applied to several specific situations in order to illustrate some of the major factors which influence selection strategies. The importance of such a study in the design stages of system development is demonstrated.

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[1] B-Specs, Volume 12, Computer Program Configuration Item Specification Network Communications Processing for Division Tactical Operations System (DTOS), CR-CS-0002-B12, 25 May 1979.

1.3.6 HUMAN FACTORS

Chapter 7.0 explores the extent to which the user is required to take action in order to get a message across a channel. Ouantitative results are presented regarding the probability that human intervention is required. The probability is found to be significant at peak hour message loads regardless of field conditions. It is noted that delays inherent in human intervention make some of the previous estimates of TOS capacity optimistic.

2.0 CRITICAL COMPONENTS

The goal of this chapter is to identify the components of the TOS communications subsystem which are critical. A component is considered critical if it is busy most of the time or causes long delays of messages in transit.

2.1 APPROACH

In order to provide a reference point for the analysis, it was necessary to establish a baseline case. This meant selecting values for a number of input parameters used in the model. These inputs are documented in the appendices. The baseline case should not be construed as representing any particular real state of TOS. Rather, its purpose is to provide a benchmark -- a reference point for the analysis.

At times throughout this document, it will be necessary to refer to certain modeling assumptions which are particularly relevant.[1] At this point it will be useful to summarize the way the model represents field conditions that TOS will encounter and to be specific about the baseline case of field conditions.

- Traffic Rate

  Different types of messages of various lengths are modeled (see appendix A). Baseline message traffic rates for each user are taken from the Traffic Projection Analysis and represent peak hour loads.

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[1]For a complete account of modeling assumptions see ARI Research Notes 80-13.

- <u>Error Rate</u>

  The perceived error rate is measured at a receiver after majority voting and before Hamming Code or other EDC procedures are applied. The units of error rate are bits per 1000. Errors are assumed to occur at random and independent of one another. Error rate is not a unit of environmental condition, but rather a unit of the receiver's perception of that condition.[1] In the baseline case, error rate is allowed to vary from zero to 15 bits per 1000.

- <u>Retransmission Stations</u>

  FM nets may be required to use retransmission stations in order to extend their range. It is assumed that no retransmission stations are necessary in the baseline case.

- <u>Voice Competition</u>

  FM nets may be used for voice as well as for digital communications. It is assumed that no voice use occurs in the baseline case.

- <u>Human Factors</u>

  Human factors are not considered in the baseline case. Human factors and their impact on TOS are discussed in chapter 7.0.

In order to analyze TOS communications in the baseline case, two measures of performance are used. The first is expected delay. The

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[1]For analysis purposes, the environment in which a link operates and the effects of environment on the link (bit error rate) can be uncoupled for separate study, i.e.: (1) an engineering study to describe the electromagnetic environments which produce bit error rates of various levels on a specified link; and (2) a system study to investigate the implications of a given bit error rate on a specified link, the source environments for those assumed error rates being immaterial to the study purposes.

expected delay along a route is the average total time it takes a message to be transmitted in one direction. Expected delay along a route is the sum of the expected delays at each component. There are two sources of delay at a component: the first is the time spent waiting for messages which have arrived earlier to be processed (waiting time); the second is the time it takes to be processed (service time). The second measure of performance is component utilization. In steady state analysis, utilization is defined as the fraction of time that a component is busy.[1]

2.2 ANALYSIS RESULTS

Exhibit 2-1 displays the average total time it takes a message to travel along any given route in the TOS baseline network. The total includes the time it takes for a message to receive acknowledgement (ACK) and processing time at the DCC. Note that delays are considerably longer on routes that use FM, which is much slower than multichannel or cable.

Exhibit 2-2 breaks down the expected delay on a maneuver battalion-DCC route into component delays. FM accounts for the vast majority of delay at zero error rate. As error rate increases, the proportion of route delay attributable to FM increases. Notice that even at zero error rate the expected delay on FM is longer than the average keying length plus transmission time. This is because there is a significant expected waiting time, reflecting the fact that at peak loads the FM nets are fairly busy.

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[1]For a thorough treatment of utilization and expected delay in queueing systems, see Queueing Systems, Volume I, Theory, and Volume II, Computer Applications, Kleinrock, 1975, John Wiley & Sons.

EXHIBIT 2-1: BASELINE EXPECTED DELAYS (SECONDS) - ZERO ERROR RATE

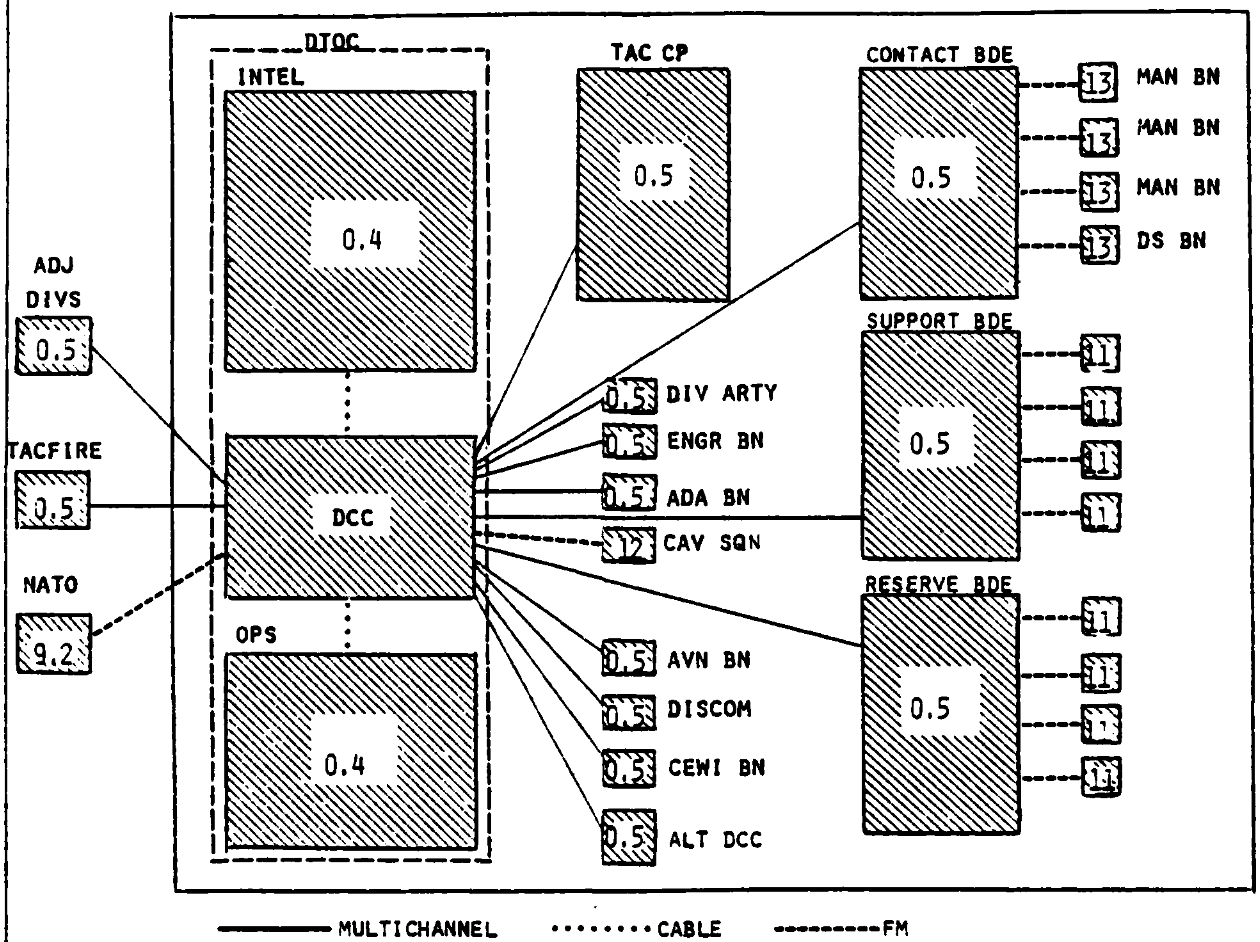

EXHIBIT 2-2: BREAKDOWN OF EXPECTED DELAY

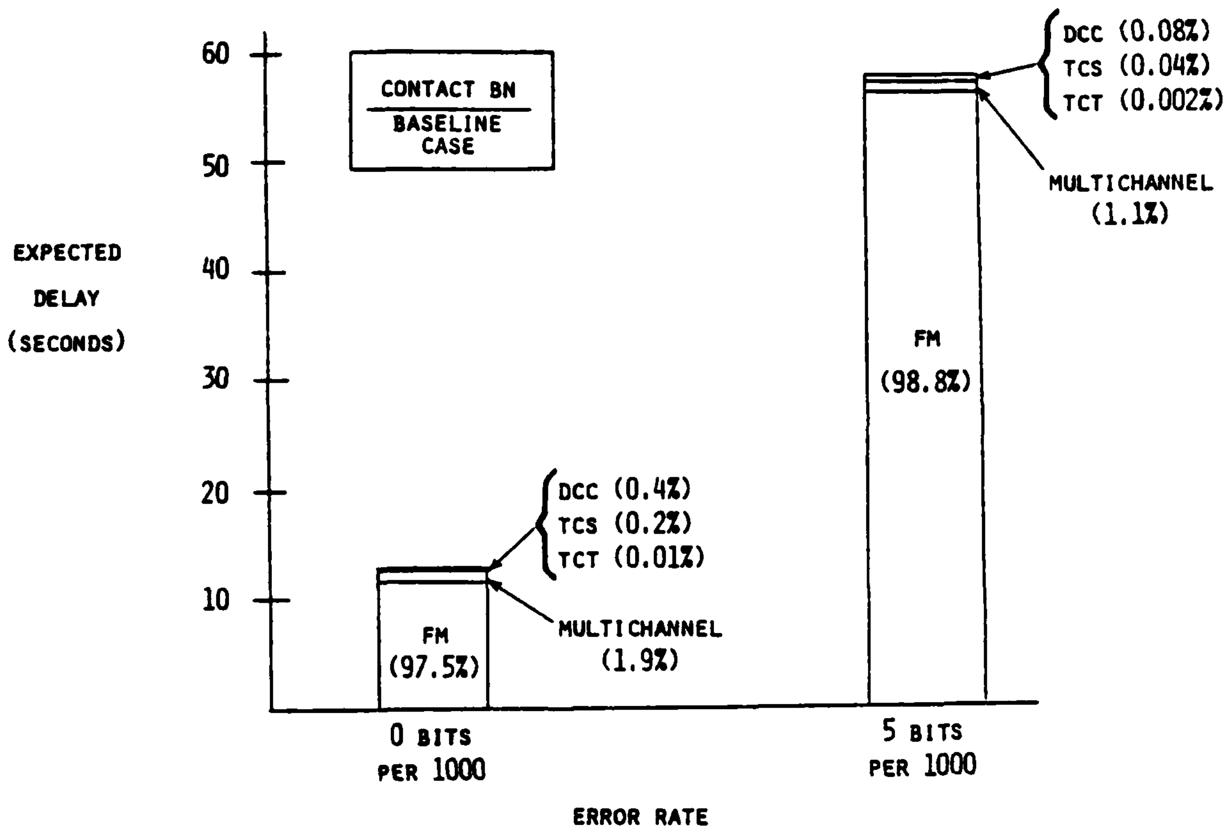

Exhibit 2-3 shows delay requirements as they appear in the A-specs. Query response times are for two-way transmissions. Since expected delay is computed for one-way transmission, Table V is taken as the user's maximum delay requirements.

Exhibit 2-4 shows the response of expected delay at a component to increasing error rate. As error rate goes up, messages receive a NAK more frequently and must be retransmitted. This ties up the channel and results in longer delays. Different FM nets respond differently to error rate because of different baseline message loads. Multichannel is not as sensitive to error rate because it is so much faster, even though it supports a higher traffic rate at baseline loads. Cable is not expected to experience significant error rates.

Exhibit 2-5 shows the utilization of the busiest of each type of component at zero error rate. The busiest FM Net is the CAV SON. The busiest disk is the message disk.

Exhibit 2-6 shows the response of component utilization to increasing error rate. As error rate goes up, messages need to be retransmitted more often, resulting in busier communications nets. As suggested by a comparison of exhibits 2-4 and 2-6, expected delay and utilization are closely related.[1]

2.3 OBSERVATIONS

At zero error rate, delays are acceptable and all components experience less than 50 percent utilization. As error rate increases, delay and utilization go up, with the FM nets suffering the most

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[1]As modeled, expected delay at a component is a function of the utilization and the service time distribution. See chapter 3.0 of ARI Research Notes 80-13.

EXHIBIT 2-3: RESPONSE TIME REQUIREMENTS

TABLE V. MAXIMUM INPUT RESPONSE TIME (MINUTES)*

USER / TYPE INPUT / SYSTEM LOAD	SIMPLE		COMPLEX		VERY COMPLEX	
	NONE	PEAK	NONE	PEAK	NONE	PEAK
LOCAL	1	1	2	2	4	6
DIRECT REMOTE	2	3	3	4	5	8
INDIRECT REMOTE	3	4	4	5	6	9

TABLE VI. MAXIMUM QUERY RESPONSE TIME (MINUTES)*

USER / TYPE INPUT / SYSTEM LOAD	SIMPLE		COMPLEX		VERY COMPLEX	
	NONE	PEAK	NONE	PEAK	NONE	PEAK
LOCAL	1	1	2	3	4	7
DIRECT REMOTE	2	3	3	5	5	9
INDIRECT REMOTE	4	5	5	7	7	15

*FROM A-SPECS, PAGE 47.

EXHIBIT 2-4: EFFECT OF TRANSMISSION ERROR RATE ON EXPECTED DELAYS

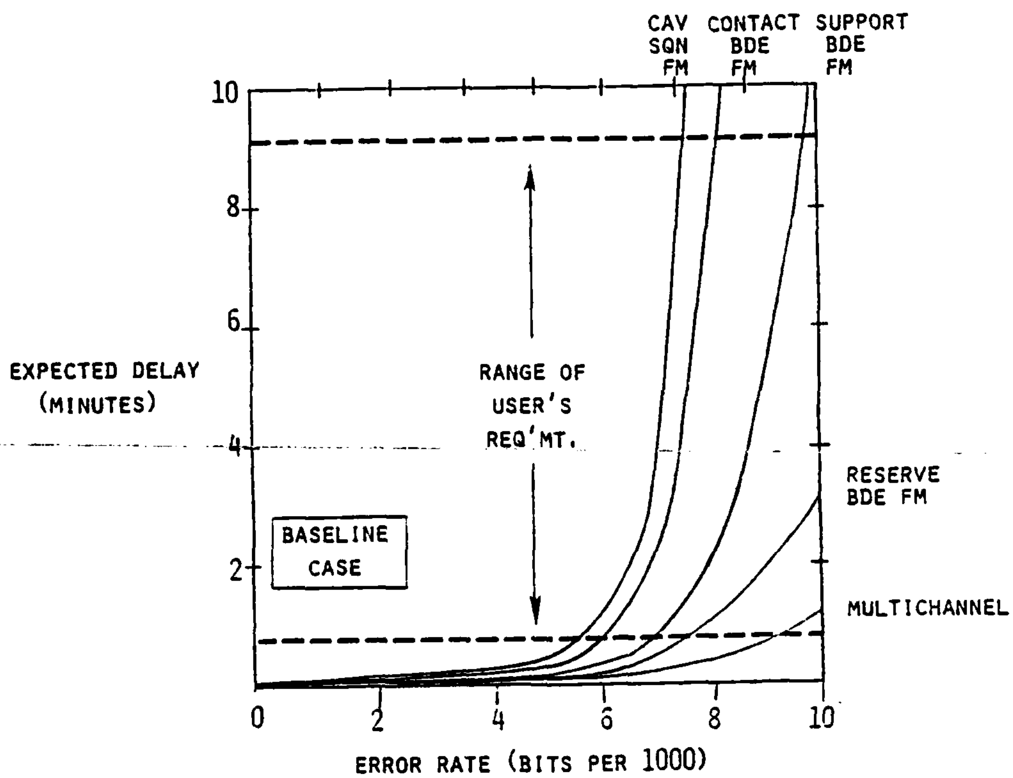


EXHIBIT 2-5: COMPONENT UTILIZATION AT ZERO ERROR RATE

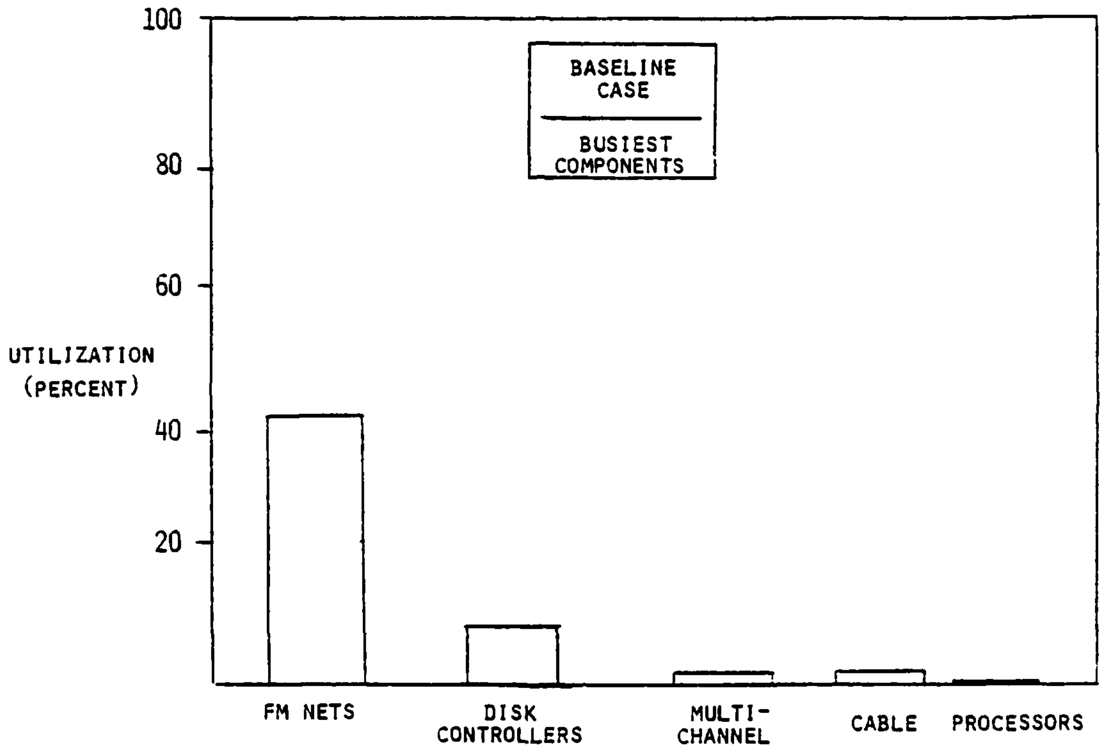
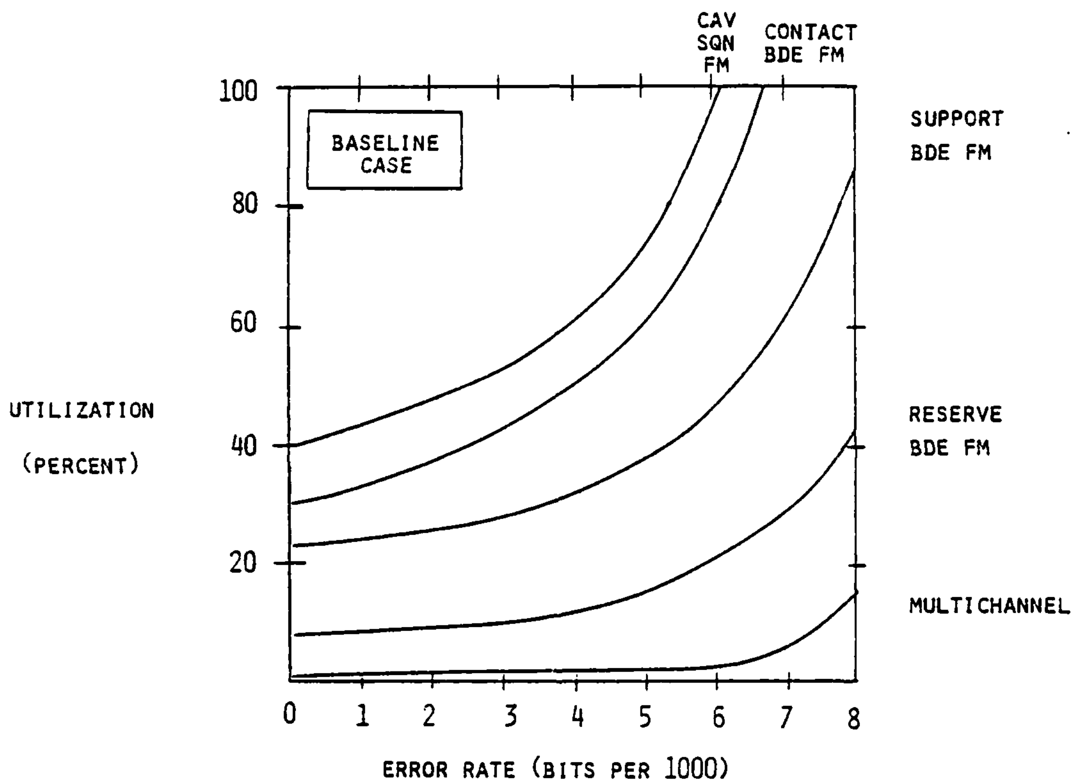


EXHIBIT 2-6: EFFECT OF TRANSMISSION ERROR RATE ON NET UTILIZATION



pronounced increases. At all error rates the FM nets cause the longest delays and experience the highest utilizations. In the field, FM nets may experience even longer delays and higher utilizations as a result of voice competition and the use of retransmission stations. It is thus demonstrated that FM nets are the critical components of the TOS communications subsystem.

3.0 OPERATING GUIDELINES

This chapter develops a basic indicator of the level of user demand which a component can safely support.

3.1 APPROACH

The provisional TOS operating procedures call for system control via control of the demand which each user places on the system. User demand is directly related to the aggregate traffic rate on a channel.[1] Traffic rate is therefore a natural system control parameter. This chapter presents an operating guideline defining the maximum level of user demand at which traffic rate can be used to control expected delay and expected queue length at a component.

3.2 ANALYSIS RESULTS

Exhibit 3-1 shows the effect of traffic rate on the expected number of messages waiting to be served at a component. Exhibit 3-2 shows the effect of traffic rate on the expected delay which a message experiences at a component. As one may suspect from comparing exhibits 3-1 and 3-2, delay and queue length are closely related.[2] For the sake of simplicity, a specific case is presented. These curves, however, are characteristic of a very general phenomenon. For all communications nets

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[1] In the analysis, changes in the aggregate traffic rate are represented by changing the total number of messages per hour while keeping the proportions of each type of message fixed.

[2] Expected delay is the expected service time multiplied by one plus the expected number of messages in the queue.

EXHIBIT 3-1: SIGNIFICANCE OF 80 PERCENT UTILIZATION

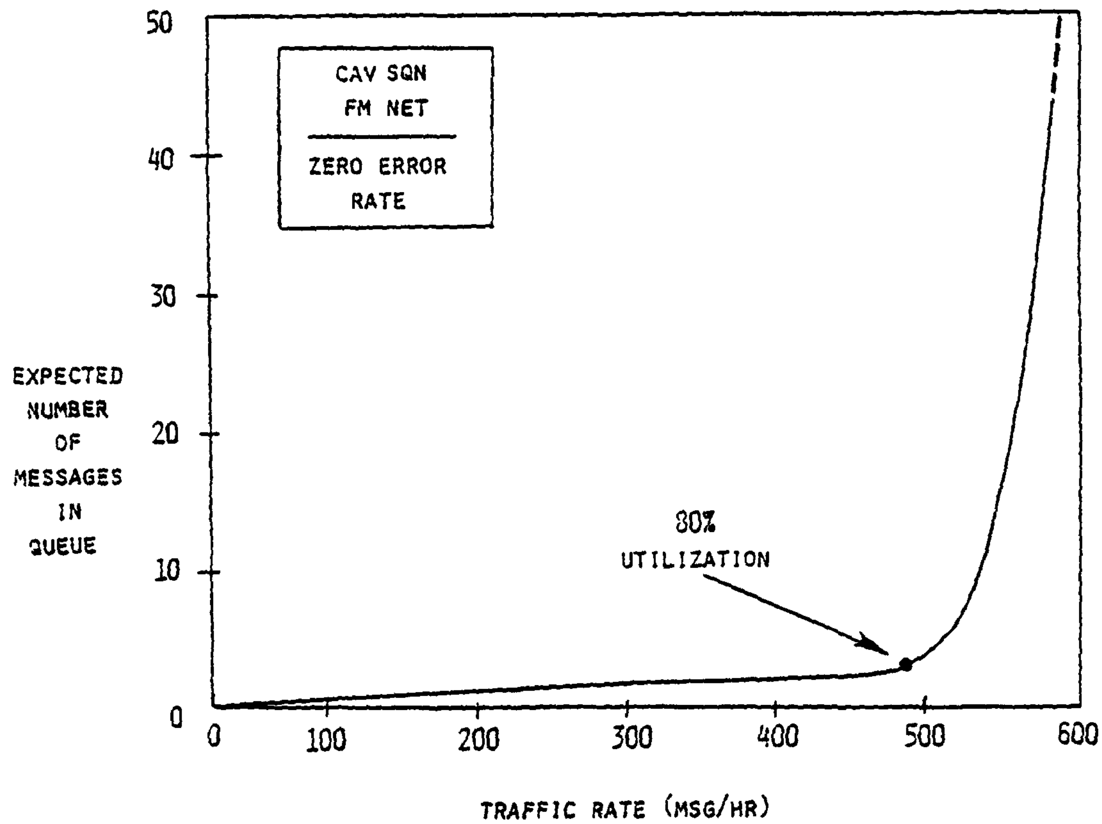
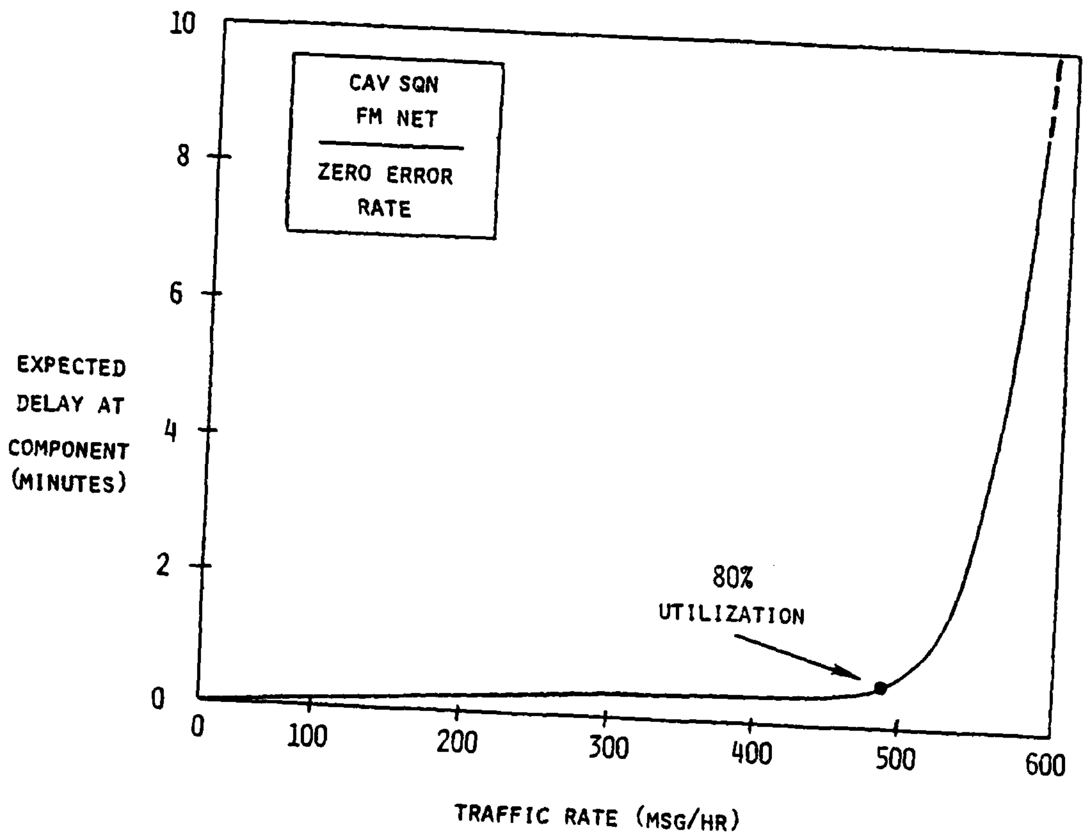


EXHIBIT 3-2: SIGNIFICANCE OF 80 PERCENT UTILIZATION



at all error rates, there is an approximately linear response to a change in traffic rate when a component operates below 80 percent utilization. Above 80 percent utilization, however, the response curve becomes almost vertical, and relatively small changes in traffic rate produce wild variations in average delay and average queue length.

3.3 OBSERVATIONS

Traffic rate is an empirically meaningful unit which is directly controllable by the user. If traffic rates are restricted below the level which causes 80 percent utilization of any component, then the system will be in a stable situation in which expected delay and expected queue lengths are under control. The system is unstable when any component operates above 80 percent utilization, and traffic rate is no longer an effective means of controlling delay and queue length. We are motivated to make the following formal definition: **component capacity is the traffic rate which results in 80 percent utilization.**

4.0 IMPACTS OF FIELD CONDITIONS

This chapter examines the effects of field conditions on communications net capacity.

4.1 APPROACH

The effects of error rate, voice competition, and retransmission stations are studied. Increased error rates reduce net capacity by causing messages to be retransmitted more often. Messages must be retransmitted whenever they are received with errors which cannot be corrected by the error detection and correction (EDC) procedures. Voice competition reduces net capacity by reducing the time that the net is available to transmit digital data. This is assumed to be the only effect of voice competition. Voice use is available only on the FM nets. In TOS communications, a keying sequence is used to cover the events of power-up, signal recognition, synchronization, and phasing. Keying sequence lengths of 0.1, 1.5, 3.0, and 6.0 seconds are possible. The use of retransmission stations involves additional power-ups and signal recognitions and therefore may necessitate the use of a longer keying sequence. The analysis assumes that the same error rate is experienced on each sublink of a train of retransmission stations. No EDC procedures are performed at the retransmission stations. Retransmission stations are used only on the FM nets.[1]

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[1]For more details on the representation of field conditions see ARI Research Notes 80-13.

4.2 ANALYSIS RESULTS

Exhibit 4-1 shows the effect of error rate on communications net capacity, using the CAV SQN FM net as an example. This is the baseline case capacity curve. As error rate increases, messages must be retransmitted a number of times before a copy with no unrecoverable errors is received. Because messages must be retransmitted, the average service time per message increases. Therefore, nets have a lower capacity at higher error rates. Because of the increased service time, the expected delay caused by a component operating at 80 percent utilization increases as capacity decreases. The black dot on the capacity curve is the point at which operating at capacity produces an expected delay of one minute. Baseline case capacity curves were produced for all the components of the TOS communications subsystem. At all error rates, the CAV SQN had the least excess capacity over and above the projected peak hour message traffic rates.

Exhibit 4-2 illustrates the effect of 25 percent voice competition on FM net capacity. The result is a 25 percent decrease in capacity. Fifty percent voice would result in a 50 percent loss of capacity, and so on.

Exhibit 4-3 shows FM net capacity when three retransmission stations are used to extend the range of the net. The use of a longer keying sequence (3.0 seconds) is necessary with three retransmission stations, because of the additional power-up and signal recognition times. This reduces capacity at all error rates. Also, since there are four sublinks that a message must cross, the compounded error rate is roughly four

EXHIBIT 4-1: BASELINE CAPACITY

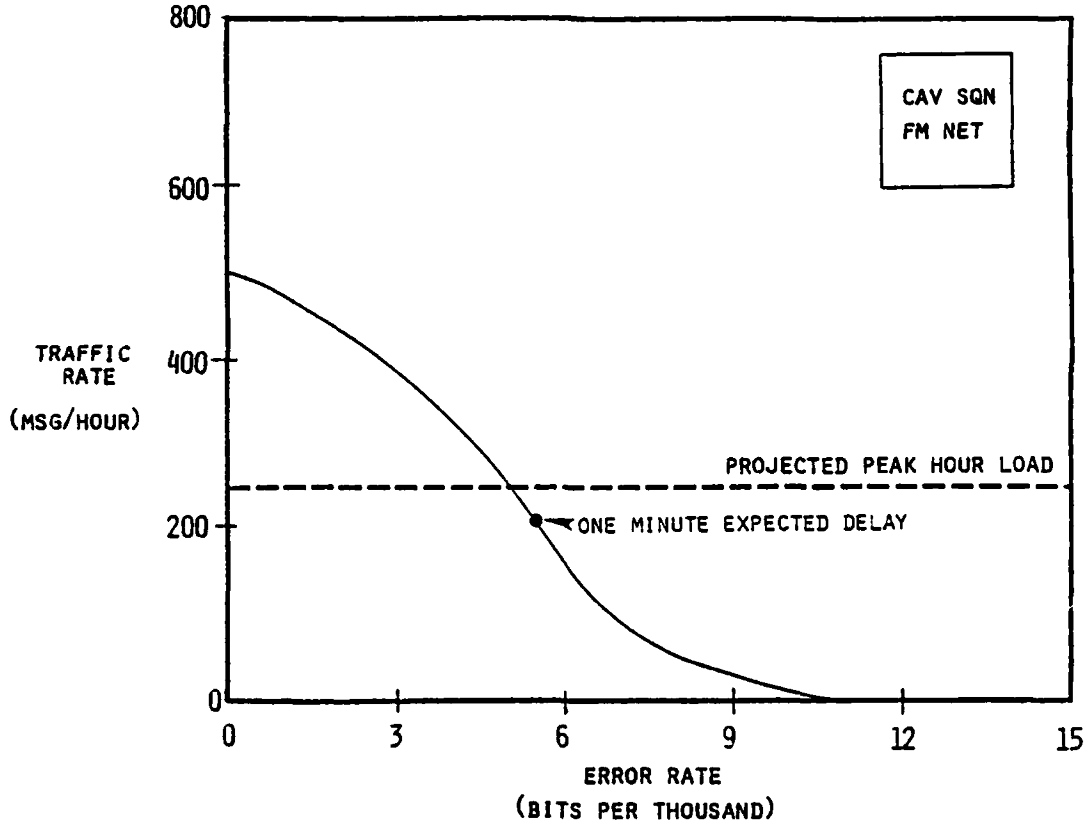


EXHIBIT 4-2: EFFECT OF VOICE COMPETITION ON CAPACITY

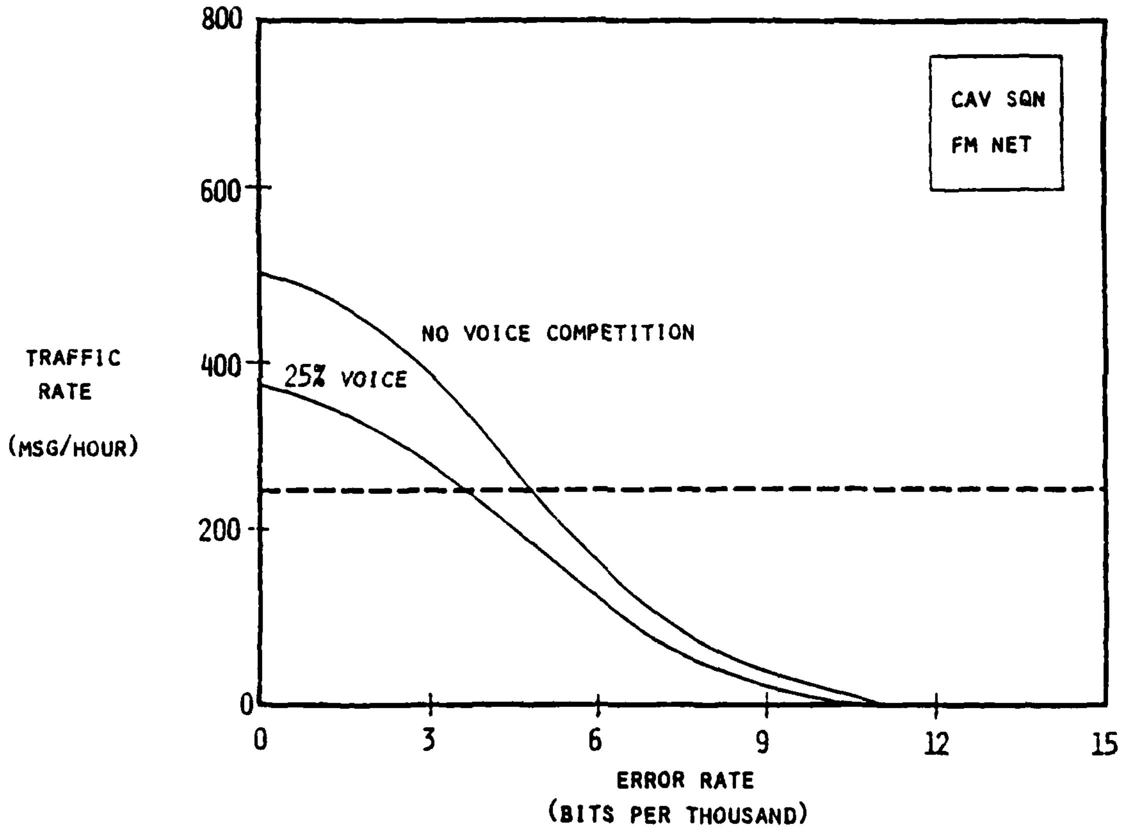
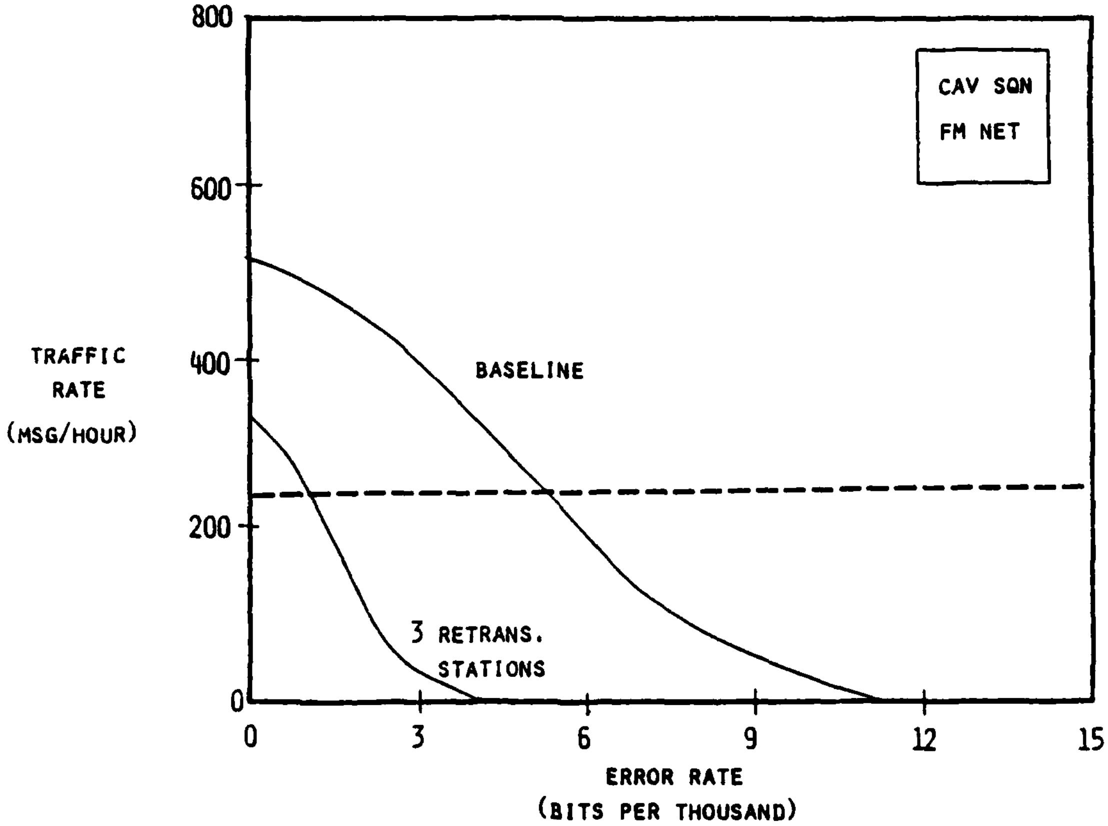


EXHIBIT 4-3: EFFECT OF RETRANSMISSION STATIONS ON CAPACITY



times that experienced on one link.[1] A vertical comparison of the curves in exhibit 4-3 assumes the same error rate in the baseline case as on any one sublink in the case of three retransmission stations.

4.3 OBSERVATIONS

The region under a capacity curve represents the area in which delay and queue length are under control (see chapter 3.0). It is of interest to identify the range of error rates for which a component has sufficient capacity to sustain the projected peak hour load. Voice competition and retransmission stations shrink this region. They also reduce capacity at zero error rate. There are combinations of field conditions in which certain components have insufficient capacity to support baseline loads at any error rate. For example, the CAV SON FM net with three retransmission stations and 25 percent voice cannot support the projected peak hour message load even at zero error rate.

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[1]Field experience indicates that transmission across several sublinks will produce an error rate roughly equal to the sum of the error rates on the sublinks. For a precise mathematical formulation of this phenomena and for a more thorough discussion of transmission errors, see ARI Research Notes 80-13.

5.0 OPPORTUNITIES FOR IMPROVEMENT

The goal of this chapter is to investigate the potential for increasing communications net capacity.

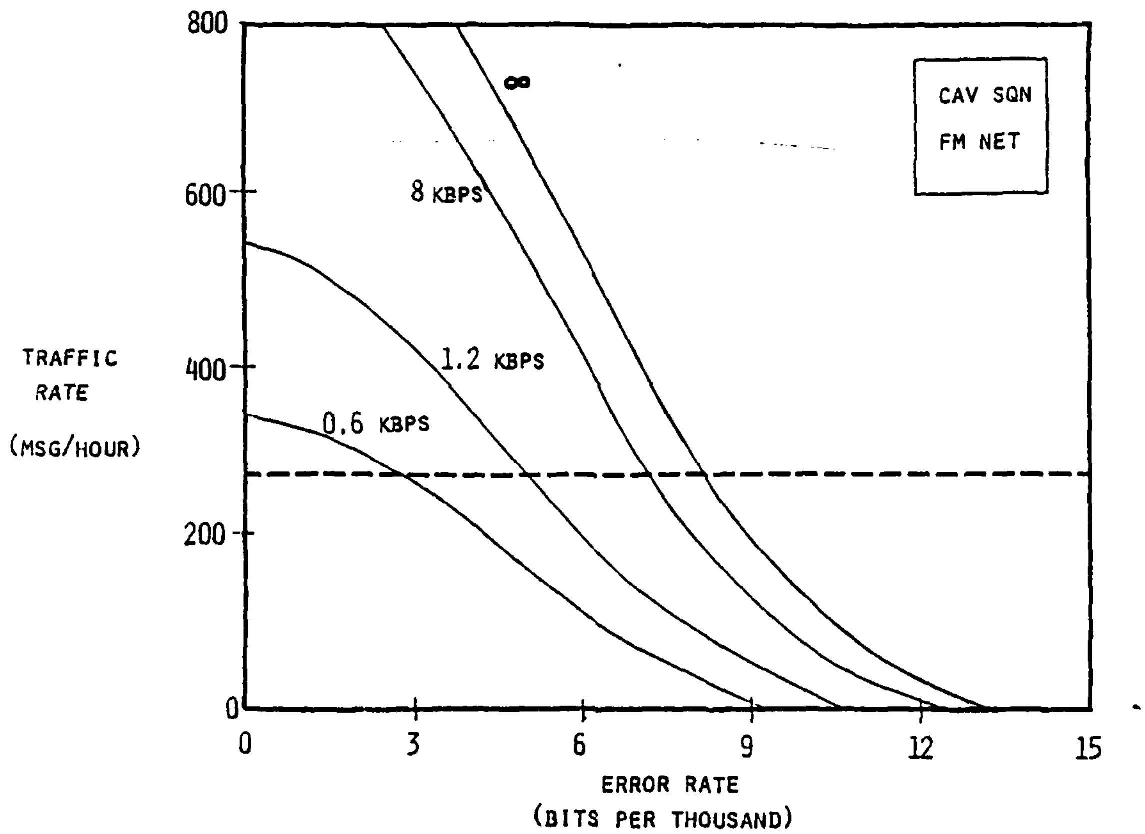
5.1 APPROACH

The effects of transmission rate, EDC procedures, and message length on communications net capacity are considered. Attention is focused on the FM nets. In the baseline case, FM nets transmit at 1.2 kbps, half duplex. The effects of higher and lower transmission rates are examined, still at half duplex. Two EDC procedures are considered as supplements to the currently planned procedure, Hamming Code. The first is multiple blocking, in which a fixed number of copies of each message are sent. The second is the retained message copy procedure (RMC). In this procedure, a message which receives a NAK is retained by the receiver until it gets another copy. A best message is assembled from both copies. If there are still errors, the receiver sends another NAK and the best message copy is retained. This process continues until a message is constructed which is free from errors. Baseline message lengths are taken from the A-specs and represent maximum lengths. This analysis investigates an across-the-board reduction in the number of characters per message by a fixed percentage.

5.2 ANALYSIS RESULTS

Exhibit 5-1 shows the effects of varying transmission rate, using the CAV SQN FM net as an example. Note that in the hypothetical case of an infinite transmission rate, capacity is still limited because of the fixed overhead involved in transmission due to the keying sequence. At

EXHIBIT 5-1: EFFECT OF TRANSMISSION RATES ON CAPACITY



eight kbps, most of the potential gain is achieved because the keying sequence accounts for most of the service time. When interpreting exhibit 5-1, it is important to realize that vertical comparison of curves assumes that the same error rate is being experienced by different hardware.

The remainder of the analysis results concern software changes. Exhibit 5-2 shows the effect of double and triple blocking on net capacity. Capacity is reduced at low error rates because multiple copies of each message are sent. At higher error rates, capacity is increased because a message receives a NAK only when the Hamming Code procedure fails to correct the same character in every copy of the message. Exhibit 5-3 shows the effect of the RMC procedure on net capacity. RMC increases net capacity at all nonzero error rates, but requires that memory be set aside to store message copies. Optimal blocking is a refinement of multiple blocking in which the number of blocks sent is allowed to vary in order to optimize net capacity.[1] It would not reduce capacity at low error rates, nor would it require additional memory. However, it would necessitate on-line monitoring in order to determine the optimal number of blocks.

Exhibit 5-4 shows the effect of a 25 percent reduction in message lengths. Reducing message length has two effects on net capacity. It reduces transmission time because fewer characters are sent. It also lowers the probability of a NAK because there are fewer characters which could be in error. Exhibit 5-5 shows why a 25 percent reduction is not very effective as a means of extending the range of tolerable error

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[1]The effect of optimal blocking on net capacity can be seen in exhibit 5-2 by moving along the highest of the capacity curves, crossing over from SB to DB, and from DB to TB, as error rate increases.

EXHIBIT 5-2: EFFECT OF MULTIPLE BLOCKING ON CAPACITY

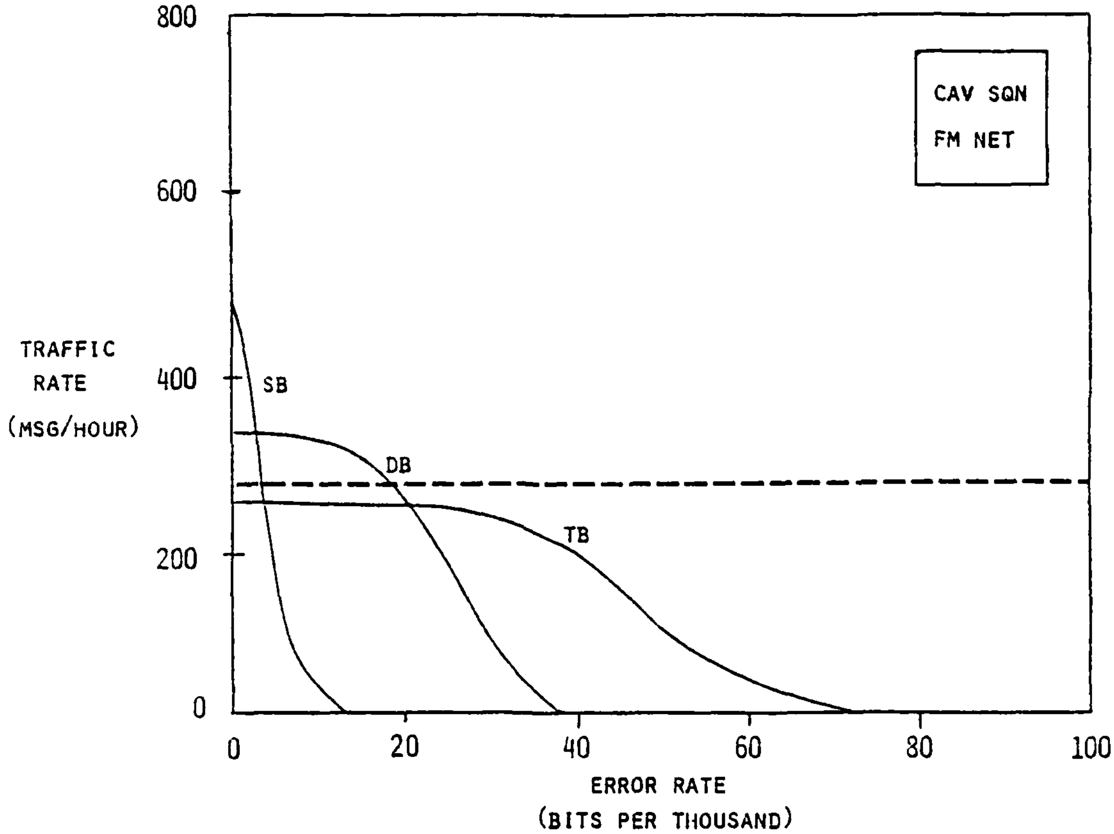


EXHIBIT 5-3: EFFECT OF RETAINED MESSAGE COPIES (RMC) ON CAPACITY

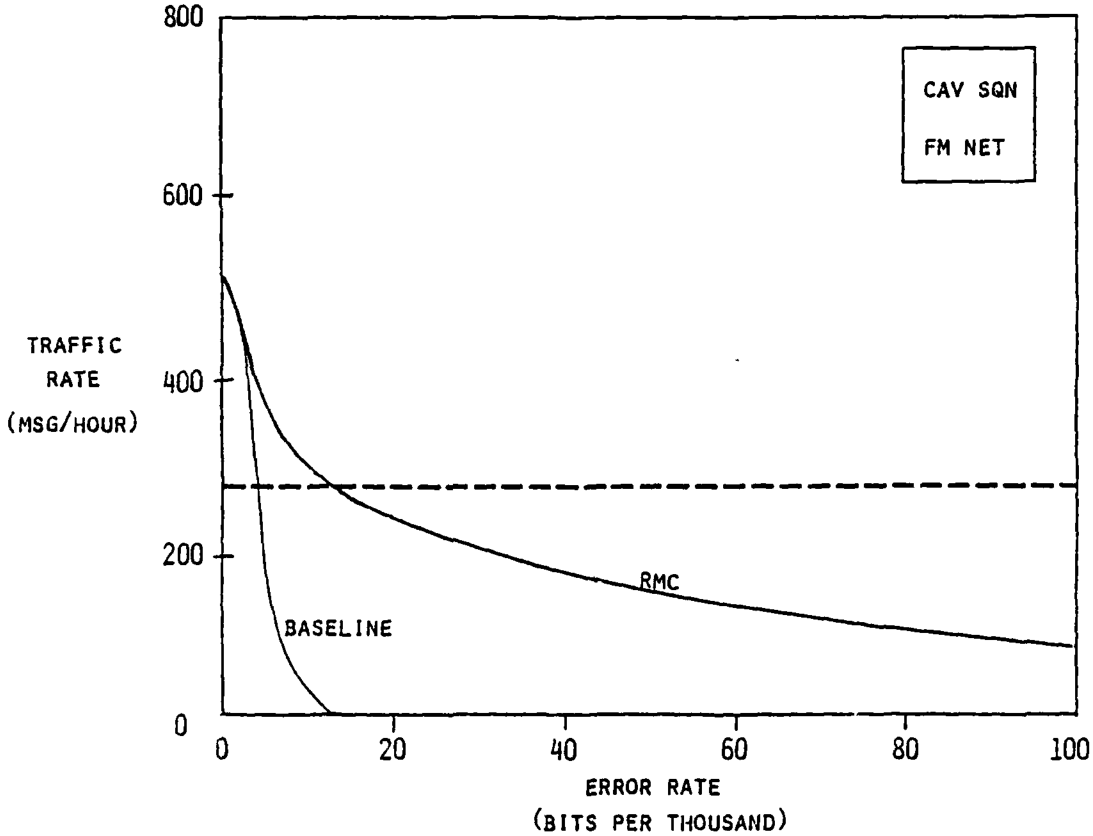


EXHIBIT 5-4: EFFECT OF MESSAGE LENGTH ON CAPACITY

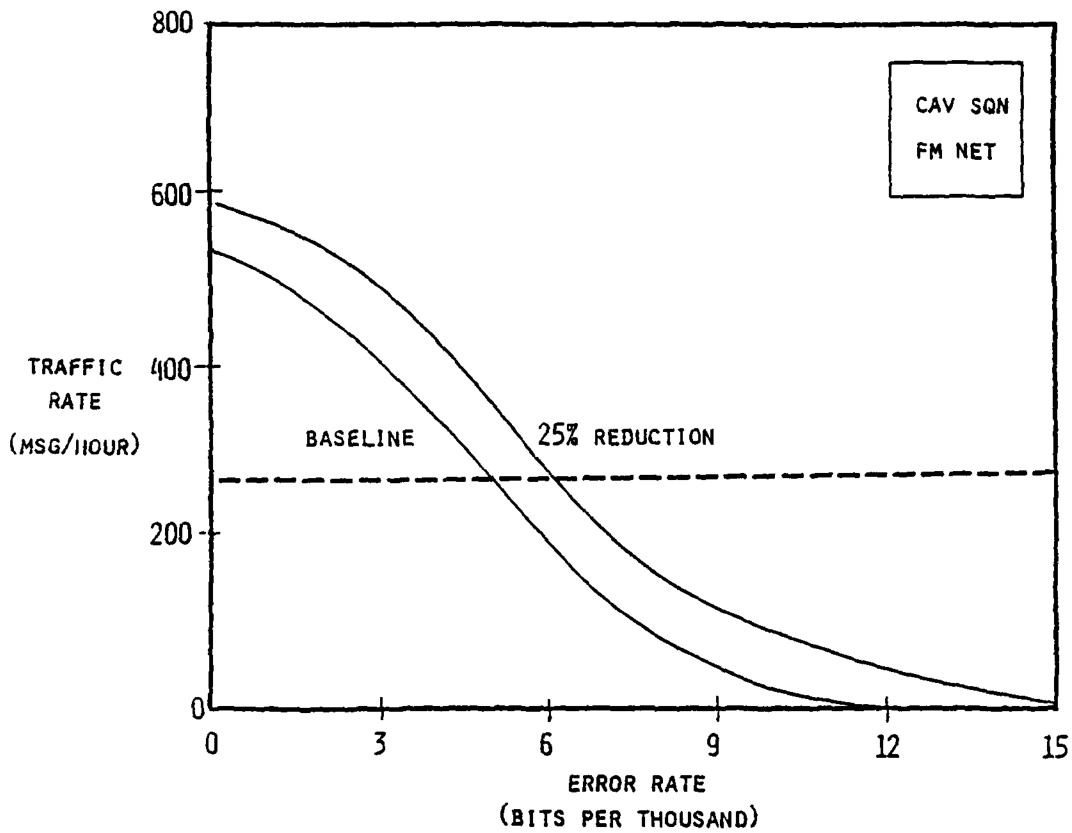
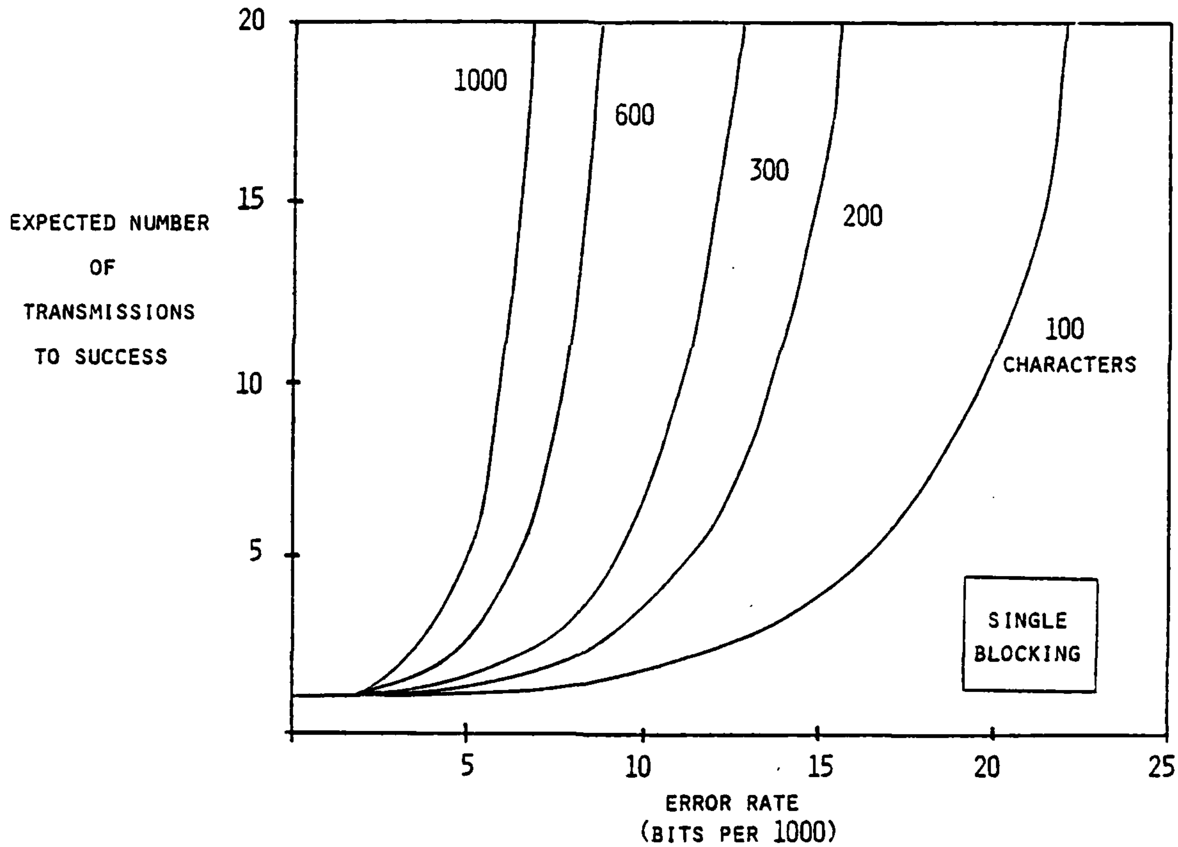


EXHIBIT 5-5: EFFECT OF MESSAGE LENGTH ON EXPECTED NUMBER OF TRANSMISSIONS TO SUCCESS



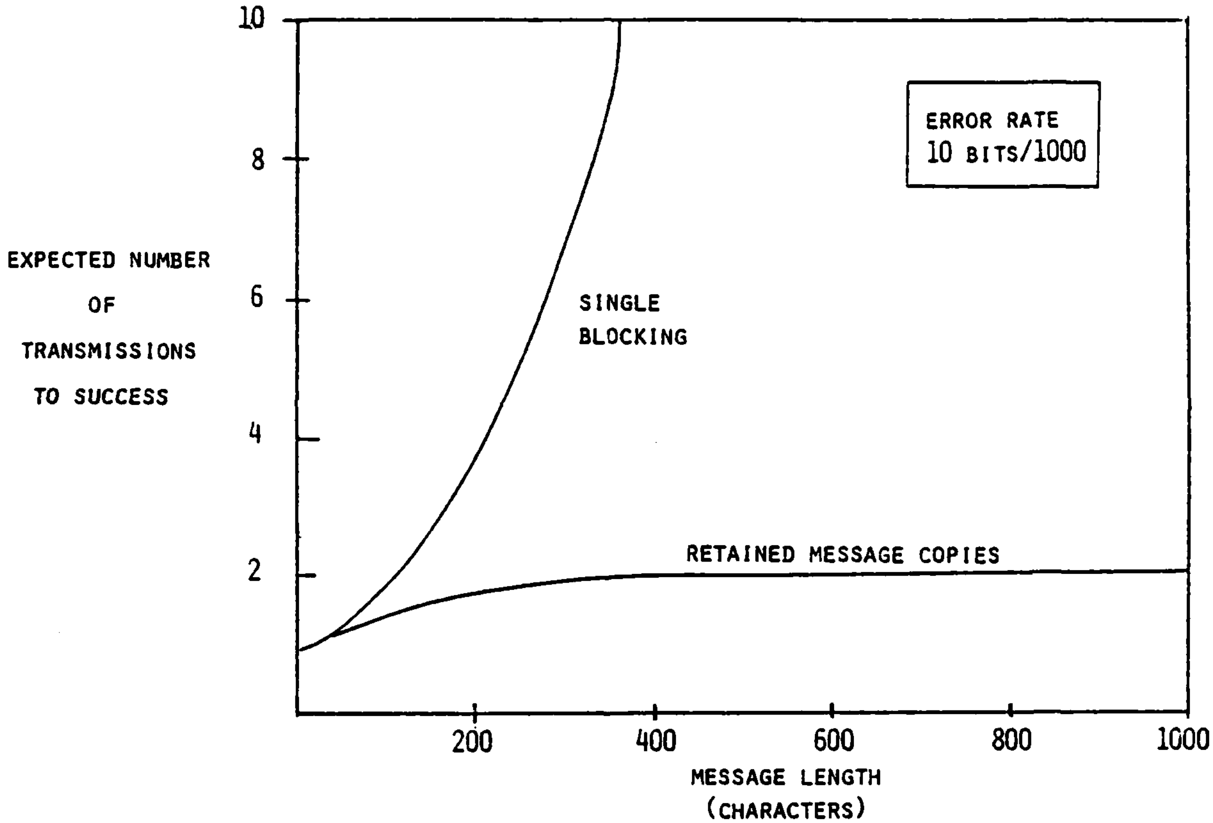
rates. Even after a 25 percent reduction in length, long messages are still too long to have a significantly reduced chance of receiving a NAK. As illustrated in exhibit 5-6, RMC is a more effective way of extending the range of tolerable error rates because it makes the system relatively insensitive to message length.

5.3 OBSERVATIONS

Increasing transmission rate provides more capacity at low error rates. It does not greatly extend the region of tolerable error rates. Multiple blocking, optimal blocking, and RMC all extend the range of tolerable error rates. They have different types of effects and different costs. Reduced message length is not an effective way to extend error rate range unless a very large percentage reduction is employed.

This chapter has demonstrated that there is considerable potential for increasing communications net capacity by a variety of methods. The next chapter addresses the question of choosing between alternative design changes.

EXHIBIT 5-6: EFFECT OF RETAINED MESSAGE COPIES ON EXPECTED NUMBER OF TRANSMISSIONS TO SUCCESS



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6.0 A METHOD FOR SELECTING DESIGN CHANGES

This chapter is a discussion of some of the factors involved in the strategy of choosing design changes. Dollar cost considerations are not included in this discussion, being beyond the scope of the analysis.

6.1 APPROACH

Exhibit 6-1 illustrates the general approach. First, the status quo (baseline case) is compared to the maximum improvement possible if all the design changes under study were to be implemented. In this way, the opportunity for improvement can be gauged, once a criterion for measuring improvement has been selected. In this analysis, improvement is measured in terms of the range of error rates at which the projected peak hour load can be supported. Finally, if there is a need for change, and if the potential gain is felt to be worth pursuing, efficient strategies for approaching the maximum gain must be investigated. In this analysis, the strategy used identifies the best single change, the best pair of changes, and so on. In this way, some of the major factors which influence selection strategies are uncovered.

6.2 ANALYSIS RESULTS

Exhibits 6-2 through 6-5 illustrate the results of our general selection strategy. The best case for a particular piece of hardware consists of implementing all of the software changes discussed in chapter 5.0, i.e., optimal blocking, RMC, and 25 percent reduced message lengths. Exhibits 6-2 and 6-3 show the best single improvement and the best pair of improvements for the CAV SQN FM net with 1.2 kbps and 8 kbps hardware respectively. In exhibit 6-4, a single improvement is all that is

EXHIBIT 6-1: SELECTION STRATEGY CONCEPT

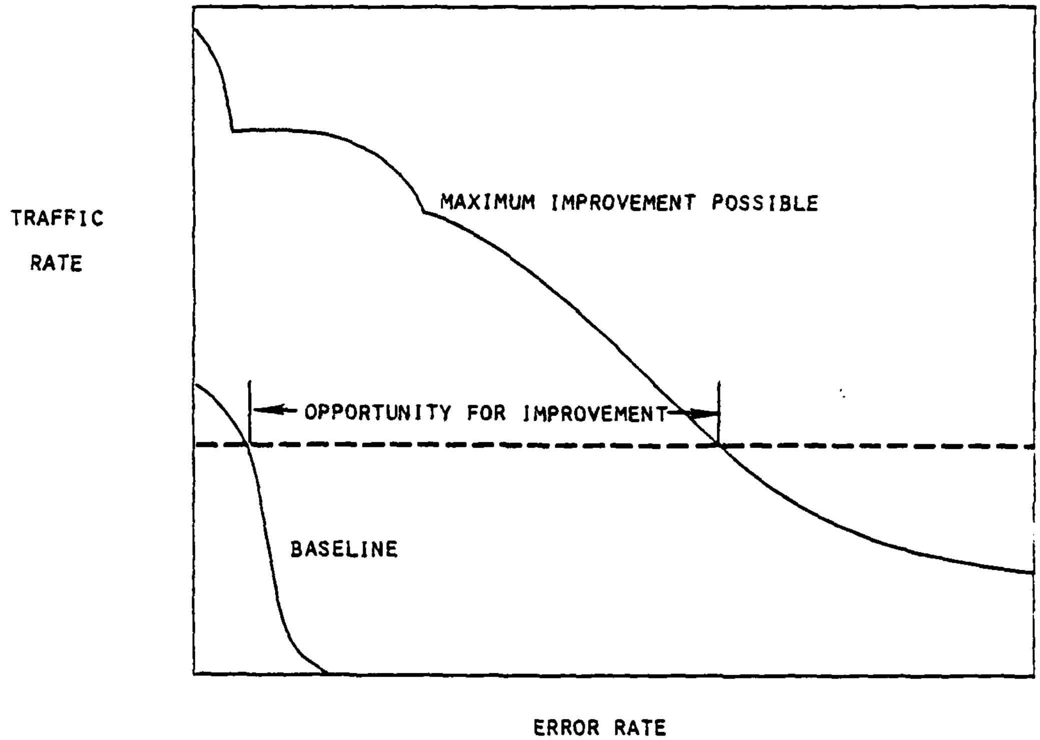


EXHIBIT 6-2: CAV SQN FM NET CAPACITY

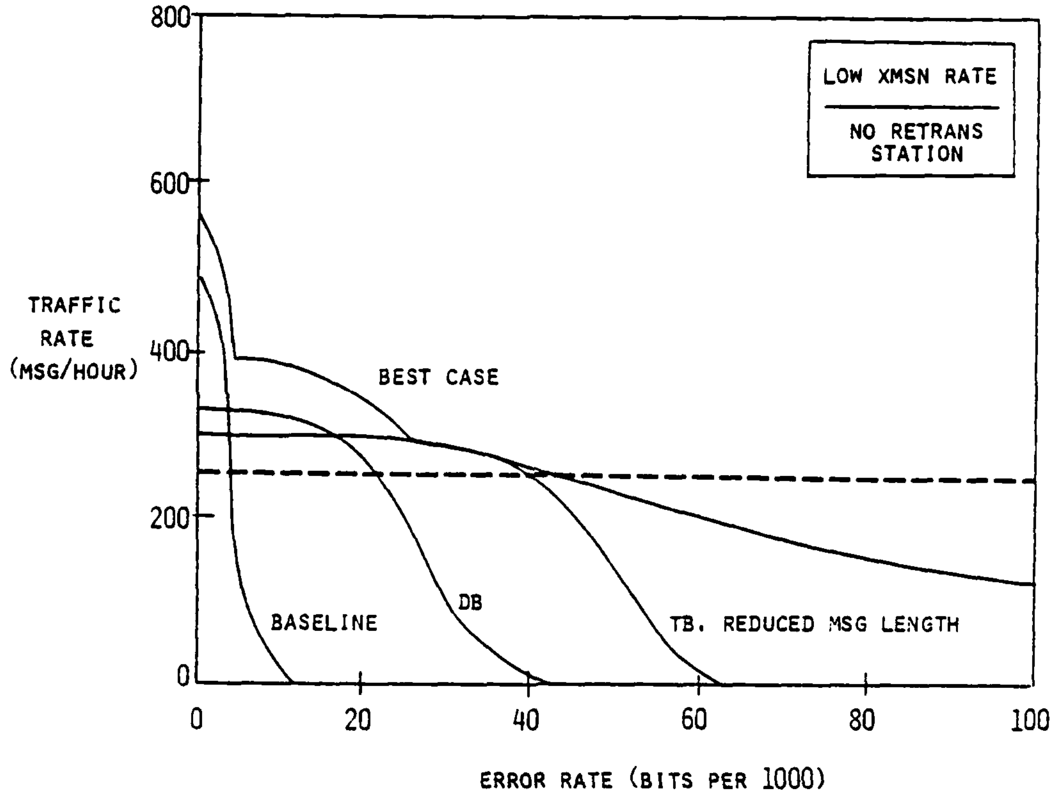


EXHIBIT 6-3: CAV SQN FM NET CAPACITY

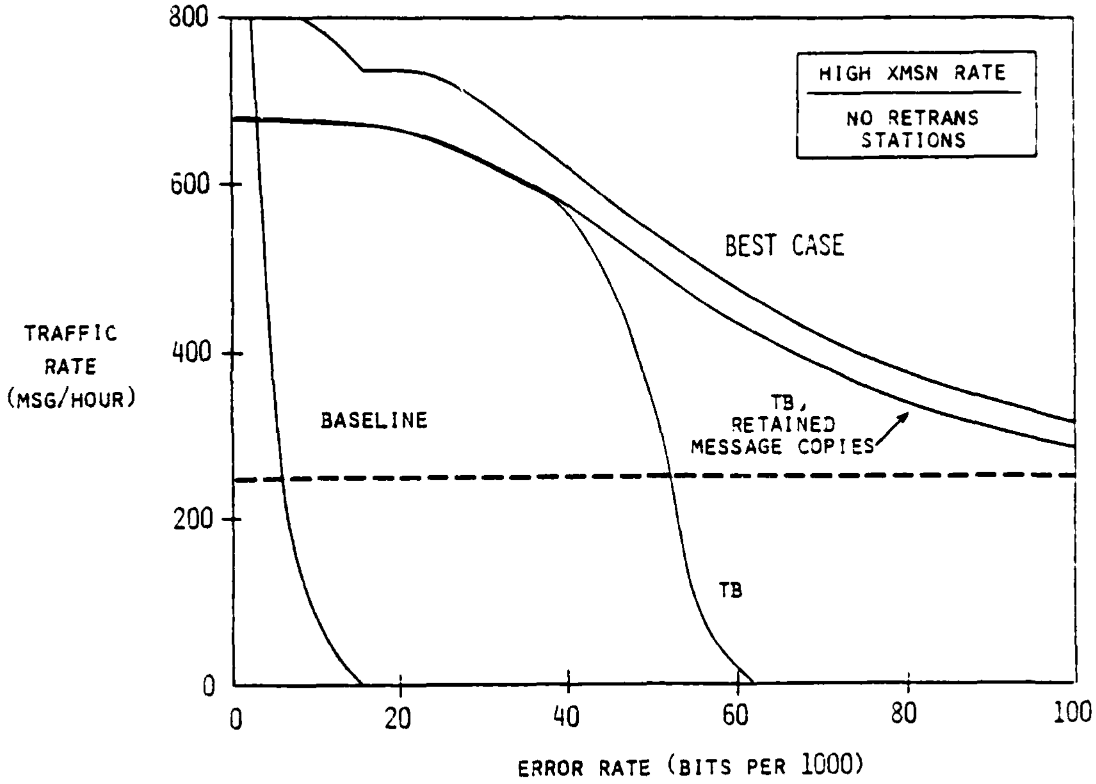


EXHIBIT 6-4: MULTICHANNEL NET CAPACITY

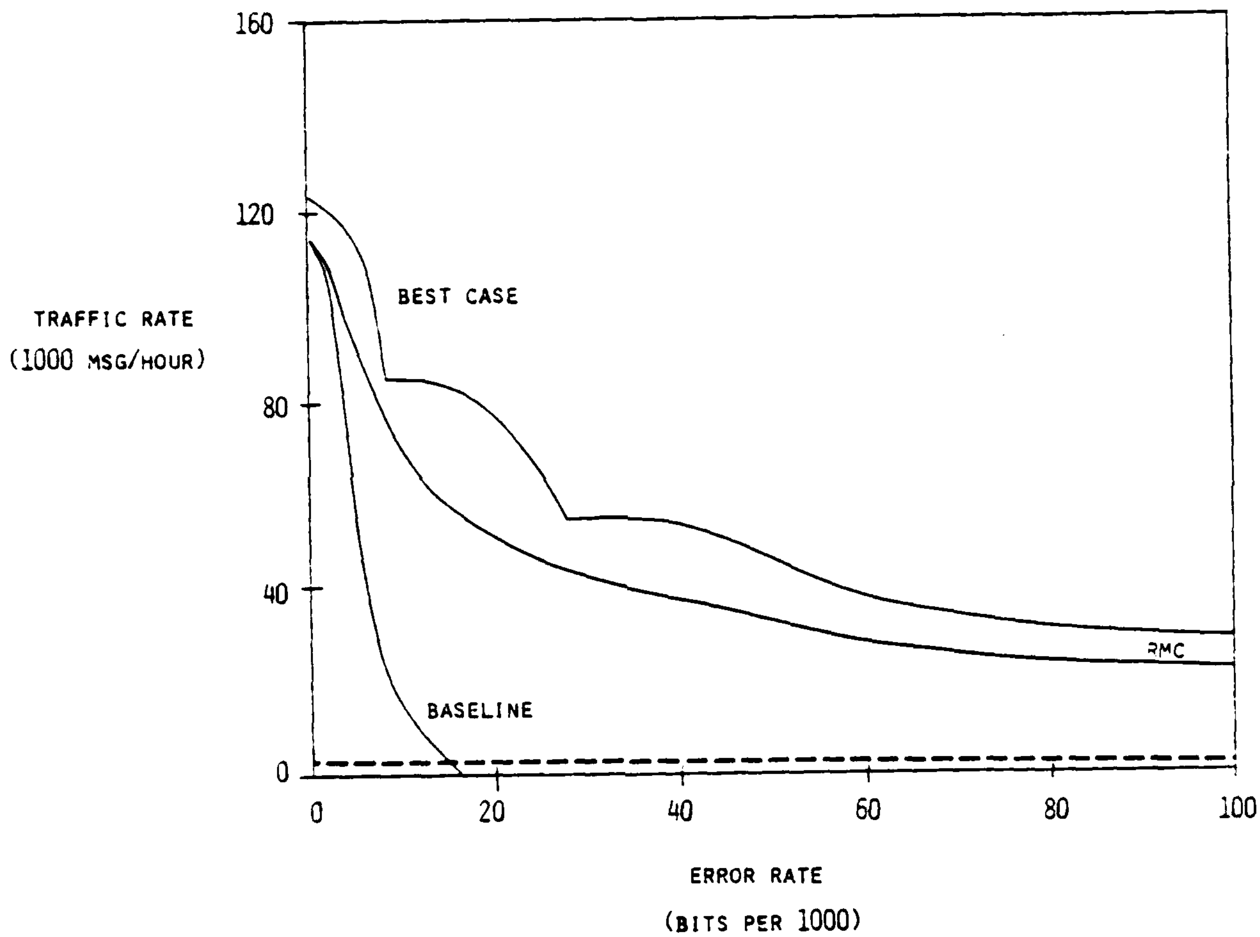
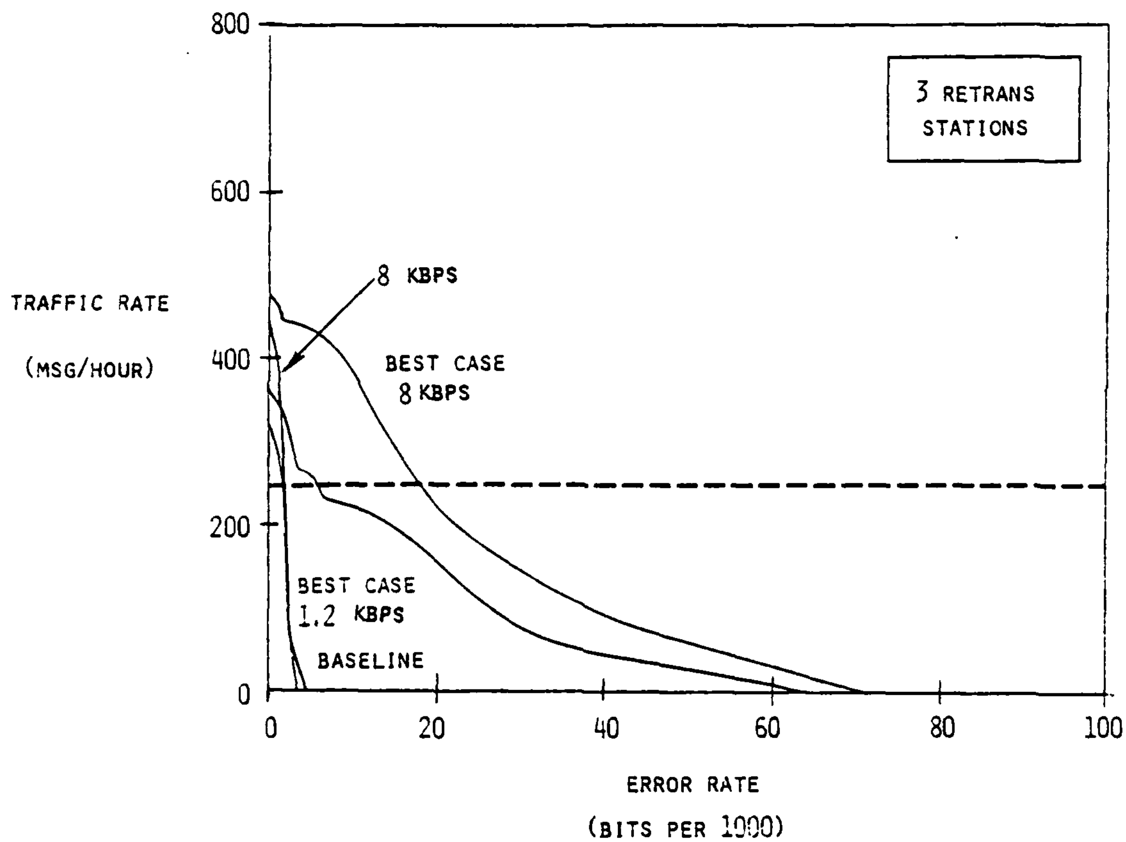


EXHIBIT 6-5: CAV SQN FM NET CAPACITY



necessary to make the multichannel net virtually immune to the adverse effects of high error rates. Exhibit 6-5 illustrates the difficulty of increasing the capacity of an FM net which uses three retransmission stations. Neither faster radios (8 kbps curve) nor software improvements (best case, 1.2 kbps) alone provide a large potential gain. But a combination of faster hardware and improved software (best case, 8 kbps) can result in significant improvement.

6.3 OBSERVATIONS

Exhibit 6-2 showed that the strategy is zero-based. That is, the best pair of changes may not include the best single change. A comparison of exhibits 6-2 and 6-3 shows that different hardware calls for different strategies. Exhibit 6-4 showed that the maximum possible increase in capacity may be far more than is needed; the user's requirements must figure into the strategy. Exhibit 6-5 showed that field conditions also alter strategy. Here we see that, if hardware is fixed, all the software changes will not significantly improve the situation. Conversely, without making some software changes, faster hardware increases capacity only where an increase is not needed. Field conditions may require that both hardware and software changes occur if the user's requirements are to be met.

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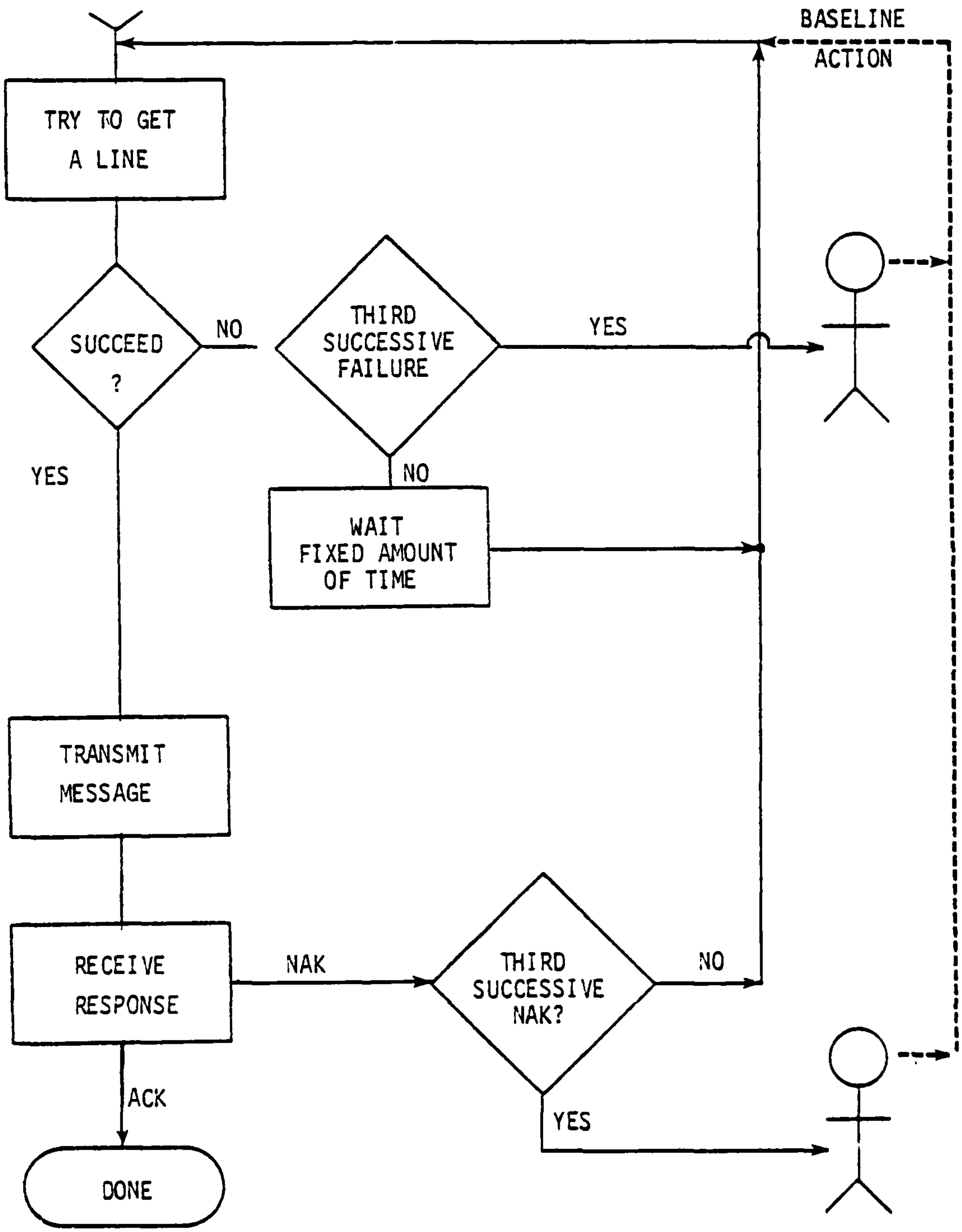
7.0 HUMAN FACTORS

Human factors introduce various uncertainty into the performance and analysis of TOS communications. These uncertainties affect the timeliness, reliability, and availability of the information in the TOS data base. This chapter explores the extent to which the user is required to take action in order to get his message across a channel. The problem of predicting the effects of user involvement on TOS is not addressed, being beyond the scope of the analysis.

7.1 APPROACH

As illustrated in exhibit 7-1, the user is at times required to exercise control over the operation of a communications link. There are two events in the transmission process which require the user to intervene. The first occurs when a node has tried three times in succession to get a line and failed each time. The second occurs when a node has tried to transmit a message and has received three consecutive NAKs. At either of these two points the user may instruct the system to try again, or choose another course of action. In any case, a human decision and action is required. This introduces further delay into the system. In addition, the frequency with which the user is required to intervene in order to get his messages through may affect his attitude towards the system, and hence, his response to the system's requests for intervention.

EXHIBIT 7-1: MESSAGE TRANSMISSION ACROSS A LINK: THE DEMAND FOR USER INTERVENTION



7.2 ANALYSIS RESULTS

Exhibit 7-2 shows the probability that a user will be told the terminal cannot get a line. This probability depends on how much serial correlation exists among the outcomes of each of the terminal's three attempts to get a line. This, in turn, depends on how long the terminal waits between tries. A longer wait tends to reduce serial correlation. The baseline case assumed no wait between tries, and hence perfect serial correlation. Once the time between tries is known, the probability of three successive failures can be computed as a function of the utilization and service time distribution of the net. As utilization increases, there is a higher probability of finding the net occupied, and hence a greater likelihood that the user becomes involved.

Exhibit 7-3 shows the probability that a message will receive three consecutive NAKs as a function of error rate. The specific case presented is characteristic of the general phenomenon. As error rate increases, there is a greater likelihood that a message will be received with one or more unrecoverable errors. If this happens three times in succession, then the user is required to intervene.

Exhibit 7-4 shows the aggregate probability that human involvement is necessary in order to transmit a message. Once again, the exact curve depends on how long the terminal is programmed to wait between attempts to get a line.

7.3 OBSERVATIONS

Increasing the time between attempts to get a line has two effects. The probability of system demand for human intervention decreases, but the expected system delay to transmit a message increases. Here is an

EXHIBIT 7-2: SYSTEM DEMAND ON THE USER:
USER TOLD NET IS OCCUPIED

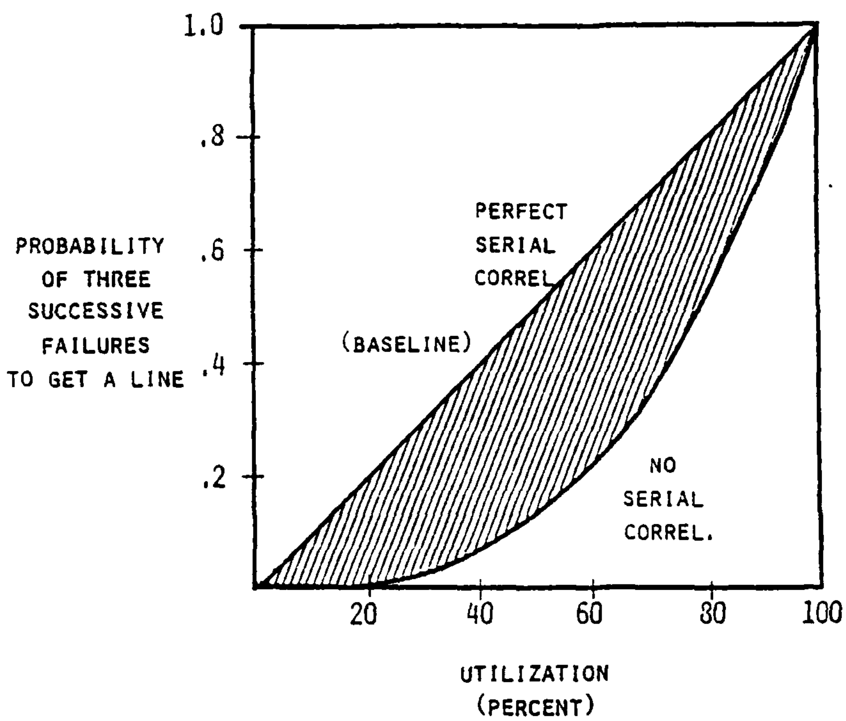


EXHIBIT 7-3: SYSTEM DEMAND ON THE USER:
USER TOLD MESSAGE WAS GARBLED

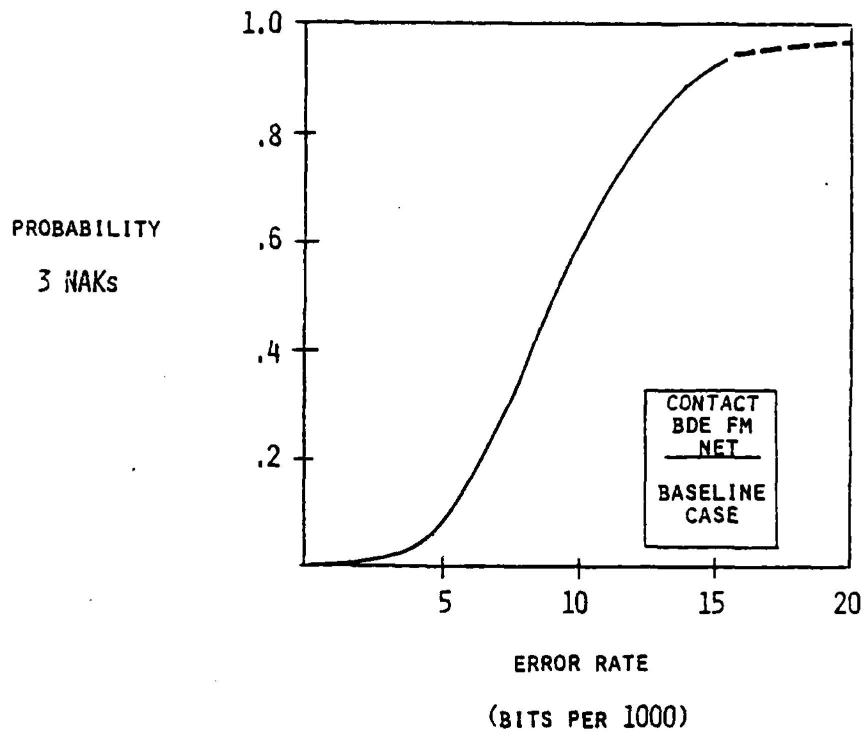
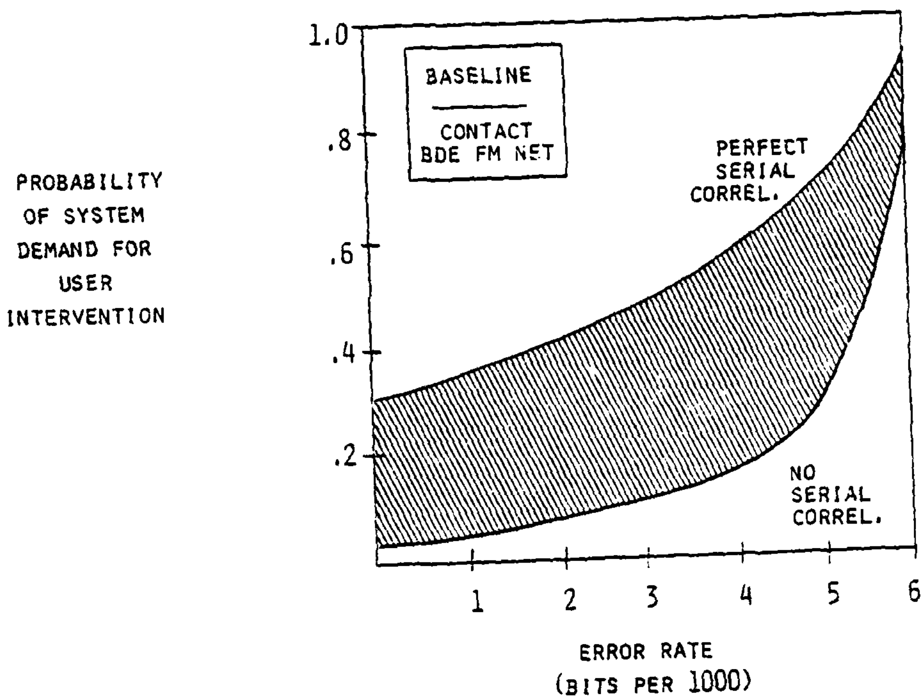


EXHIBIT 7-4: SYSTEM DEMAND FOR USER INTERVENTION



interesting tradeoff between human resources and system resources. The solution to the problem of finding the optimal time between tries requires an integrated approach. One must consider the effects on all of the elements of the communications process, including the user.

Regardless of what error rates FM nets may experience in the field, there is a significant probability that the user will become involved in the process of message transmission. One observes in exhibit 7-4 that even at zero error rate the probability that the user must intervene to get his message through can be as high as 0.3.

It should also be noted that the probability of system demand for user intervention on the contact brigade FM net approaches certainty at about six bits per 1000 error rate. Previous analysis has determined that this net has enough capacity to support a traffic rate of about 200 msg/hour at this error rate (see exhibit 2-6). Consequently human factors may have a significant impact even though the system is operating within its capacity.

There are many ways in which human factors can affect TOS performance. Only a few have been discussed here. However, even this limited study has revealed that an integrated approach to system design is required, including an analysis of human factors.

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APPENDIX A

BASELINE DEFINITION

This appendix documents the input parameters used in the baseline case of the analysis. Values of the input parameters are tabulated in appendix B: Computer Program Inputs and Outputs. The remainder of this appendix explains the construction of the data base. Data sources are given. Necessary assumptions and modifications are explained and justified.

A.1 COMPONENTS

The analytic model used in the analysis explicitly represents the various components of TOS. The modeling of TOS components is documented elsewhere.[1]

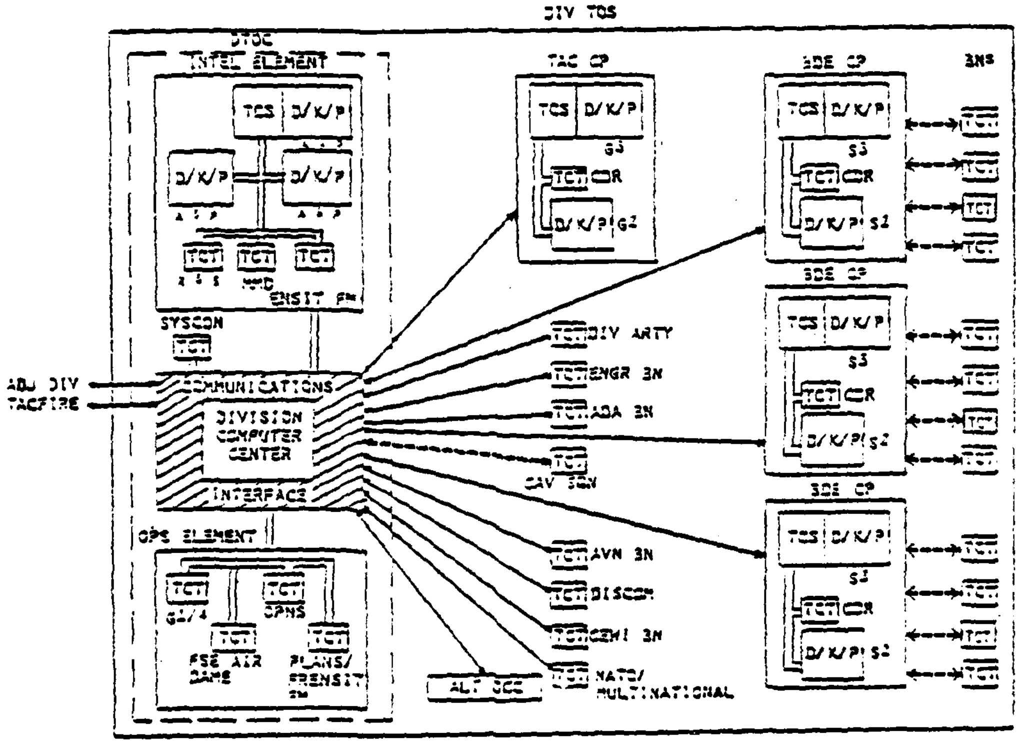
A.2 COMPONENT CONFIGURATION

Exhibit A-1 shows the component configuration used in the baseline case. The configuration is that contained in figure 1 of the A-Specs, subject to the following modifications and assumptions:

- TACFIRE is modeled as a TCT on the division multichannel net.
- ADJ DIV is modeled as a TCS on the division net. This is how the DCC would recognize another division's DCC.
- INTEL and each BDE are each modeled as a single TCS. OPS and NATO are each modeled as a single TCT. This simplification was

[1]See ARI Research Notes 80-13.

EXHIBIT A-1: DTOS BASELINE NETWORK CONFIGURATION



LEGEND:

CABLE (FDX)

MULTICHANNEL (FDX)

FM (HDX)

SOURCE: A-SPECS

made in order to conform to the list of users referenced in tables B and C of Traffic Projection Analysis, which provided the peak hour message traffic rates;

- CAV TRPs are assumed to communicate with TOS via the CAV SQN TCT. This change resulted from updated information received from the office of the TOS Project Manager (PMTOS);
- SYSCON is not included in the baseline configuration for two reasons:
  1) in order to analyze the communications subsystem properly, it was necessary to suppress internal controls; and
  2) it was not known what forms controls might take.

A.3 COMMUNICATIONS SYSTEM

Communications system data are taken from the B-Specs, Volume 12. Where choices were made, primary means, if known, were employed; otherwise, the most optimistic choices were made.

A.3.1 FM NETS

FM nets are assumed to operate at 1.2 kbps, half duplex, 1.5 second keying duration. An FM net connects NATO to the DCC, another FM net connects the CAV SQN to the DCC, and each BDE has an FM net with which to communicate with its battalions.

A.3.2 DIVISION MULTICHANNEL NET

The division net is a microwave net supporting multiple channels. It is assumed to operate at 32 kbps, full duplex, 0.1 second keying duration. The division net connects the DCC to the following:

- Contact BDE;
- Support BDE;
- Reserve BDE;
- TAC CP;
- DIV ARTY;
- ENG BN;
- ADA BN;
- AVN BN;
- CEWI BN;
- DISCOM;
- TACFIRE;
- ADJ DIV; and
- ALT DCC.

A.3.3 CABLE

Cable is assumed to operate at 32 kbps, full duplex, zero keying duration. INTEL and OPS are connected to the DCC via cable.

A.4 MESSAGE DATA

Appendix B contains a list of the message types used in the baseline case. It also contains message lengths, depending on whether the message originates at the DCC (output messages) or with the user (input messages). Data came from the Traffic Projection Analysis and the A-Specs, subject to the following modifications and assumptions:

- One type of output message corresponds to each input message type. Since TPA data did not appear in this format, the following adjustment was made: CORR, FILTER, and IMR output messages are absorbed into the other output message types. For

example, if a FILTER were to cause an output message to be sent which consisted of data from the ESD file, this would count as an ESD output message.

- SYSCON messages are not used since SYSCON is not included in the baseline configuration (see paragraph A.2).
- The alternate DCC is assumed to be updated in batch mode, resulting in no communications burden.
- Input message lengths and output message lengths are fixed for each message type.
- Maximum message lengths were used when available. Otherwise, best estimates of average lengths were used.
- Queries are modeled as a separate message type.

A.5 PROCESSOR DATA

Processing time estimates for the activities performed by the various processors[1] were provided by the software developers (Calculon). When the initial estimates provided were ranges, i.e., upper and lower bounds, the upper bound estimates of the processing times were used as the input values.

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[1]A detailed explanation of the activities of each type of processor (TCT, TCS, FEP) is provided in ARI Research Notes 80-13.

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APPENDIX B

COMPUTER PROGRAM INPUTS AND OUTPUTS

This appendix presents a listing of the input file defining the baseline case to the computer program implementation of the TOS model in exhibit B-1 and a listing of the output of the computer program for the baseline case in exhibit B-2. The output listing consists of five tables. Table 1, Route Summary Statistics, lists each user on the TOS network, the expected total delay a message experiences, and the aggregate traffic rate to and from the user. Users are ranked by decreasing expected delay. Table 2, Message Summary Statistics, lists each type of message, the expected delay each type of message experiences from its origination to its termination, and the aggregate rate at which each type of message enters the system. Messages are ranked by decreasing expected delay. Table 3, Processor Summary Statistics, lists each node in the network (the FEP for the DCC), the expected delay a message experiences at that processor, the expected queue length at the processor, and the utilization of the processor. Table 4, Channel Summary Statistics, lists the communications nets, the expected delay a message experiences at the net, the expected queue length at the net, the traffic rate on the net, and the utilization of the net. Nets are ranked by decreasing expected delay. Table 5, DCC Summary Statistics, lists the three remaining components of the DCC (one DBP CPU, and the two disk controllers), the expected delay of a message at each component, the expected queue length, traffic rate, and utilization. Components are ranked by decreasing expected delay. Note: in the computer listings, 0.0 denotes true zero, while 0.000 denotes a number greater than zero but less than 0.0005.

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EXHIBIT B-1: PROGRAM INPUTS

```
**************************************************
*****                                        *****
*****          SYSTEM CONFIGURATION          *****
*****                                        *****
**************************************************
```

** MANEUVER BRIGADES **

UNIT NAME	COMMUNICATIONS LINK W/ FEP	PROCESSOR TYPE	NUMBER OF TEMPLATES
BDE1	MULTI	TCS	10
BDE2	MULTI	TCS	10
BDE3	MULTI	TCS	10

** MANEUVER BATTALIONS **

UNIT NAME	COMMUNICATIONS LINK W/ BRIGADE	PARENT BRIGADE	PROCESSOR TYPE
BN1.1	BDE1 FM	BDE1	TCT
BN1.2	BDE1 FM	BDE1	TCT
BN1.3	BDE1 FM	BDE1	TCT
BN1.4	BDE1 FM	BDE1	TCT
BN1.5	BDE1 FM	BDE1	TCT
BN2.1	BDE2 FM	BDE2	TCT
BN2.2	BDE2 FM	BDE2	TCT
BN2.3	BDE2 FM	BDE2	TCT
BN2.4	BDE2 FM	BDE2	TCT
BN2.5	BDE2 FM	BDE2	TCT
BN3.1	BDE3 FM	BDE3	TCT
BN3.2	BDE3 FM	BDE3	TCT
BN3.3	BDE3 FM	BDE3	TCT
BN3.4	BDE3 FM	BDE3	TCT
BN3.5	BDE3 FM	BDE3	TCT

** OTHER TOS USERS **

UNIT NAME	COMMUNICATIONS LINK	PROCESSOR TYPE
TAC CP	MULTI	TCS
DIV ARTY	MULTI	TCT
ENG BN	MULTI	TCT
ADA BN	MULTI	TCT
AVN BN	MULTI	TCT
CEWI BN	MULTI	TCT
CAV SQN	CAV SQN	TCT
DISCOM	MULTI	TCT
INTEL EL	CABLE	TCS
OPS EL	CABLE	TCT
TACFIRE	MULTI	TCT
ADJ DIVS	MULTI	TCS
NATO	NATO FM	TCT

EXHIBIT B-1: PROGRAM INPUTS

(Continued)

COMMUNICATIONS SYSTEM

CHANNEL NAME	NUMBER OF LINES	X-MISSION RATE (CHARA/SEC)	KEYING SEQUENCE (SECONDS)	UNAVAILABLE CAPACITY (FRACTION)
CABLE	2	2670	0.0	0.0
MULTI	12	2570	0.1	0.0
CAV SCN	1	100	3.00	0.0
NATO FM	1	100	3.00	0.0
3DE1 FM	1	100	3.00	0.0
3DE2 FM	1	100	3.00	0.0
3DE3 FM	1	100	3.00	0.0

MESSAGE DATA

MESSAGE NAME	ORIGINATOR	MEAN LENGTH	DSP TIME	MSG DISK READS/WRITES	DATA DISK READS/WRITES	MSG OUT SAME ROUTE	MSG OU OTHER RO
ESD.I	USER	560	1.000	4	1	NONE	ESD.O
EOB.I	USER	450	1.000	4	1	NONE	EOB.O
ICM.I	USER	590	1.000	4	1	NONE	ICM.O
TER.I	USER	319	1.000	4	1	NONE	TER.O
SDL.I	USER	232	1.000	4	1	NONE	NONE
NAI.I	USER	242	1.000	4	1	NONE	NAI.O
SWF.I	USER	1160	1.000	4	1	NONE	SWF.O
FLM.I	USER	143	1.000	4	1	NONE	NONE
UTO.I	USER	426	1.000	4	1	NONE	UTO.O
UTD.I	USER	475	1.000	4	1	NONE	UTD.O
BIR.I	USER	548	1.000	4	1	NONE	BIR.O
RELA.I	USER	1690	1.000	4	0	NONE	RELA.O
QERY.I	USER	60	1.000	4	1	QERY.O	NONE
ESD.O	TOS	130	1.000	4	1	NONE	NONE
EOB.O	TOS	192	1.000	4	1	NONE	NONE
ICM.O	TOS	138	1.000	4	1	NONE	NONE
TER.O	TOS	139	1.000	4	1	NONE	NONE
SDL.O	TOS	106	1.000	4	1	NONE	NONE
NAI.O	TOS	112	1.000	4	1	NONE	NONE
SWF.O	TOS	131	1.000	4	1	NONE	NONE
FLM.O	TOS	169	1.000	4	1	NONE	NONE
UTO.O	TOS	272	1.000	4	1	NONE	NONE
UTD.O	TOS	271	1.000	4	1	NONE	NONE
BIR.O	TOS	175	1.000	4	1	NONE	NONE
RELA.O	TOS	1690	1.000	4	0	NONE	NONE
QERY.O	TOS	200	1.000	4	1	NONE	NONE

PROCESSOR DATA

** DCC **

MEAN DATA DISK ACCESS TIME (MILLISEC)	MEAN MSG DISK ACCESS TIME (MILLISEC)	NUMBER OF TEMPLATES	FEP CPU TIME TO INITIATE PER MSG (MILLISEC)	FEP CPU TIME TO INITIATE PER CHARA (MILLISEC)	FEP CPU TIME TERMINATE PER MSG (MILLISEC)	FEP CPU TIME TERMINATE PER CHARA (MILLISEC)
38.300	38.300	0	0.200	0.0	0.200	0.0

** CPU TIME TO: **

	ORIGINATE PER MSG (MILLISEC)	ORIGINATE PER CHARA (MILLISEC)	SEND PER MSG (MILLISEC)	SEND PER CHARA (MILLISEC)	RECEIVE PER MSG (MILLISEC)	RECEIVE PER CHARA (MILLISEC)	TEMPLATE PER MSG (MILLISEC)	TEMPLATE PER CHARA (MILLISEC)	TERMINATE PER MSG (MILLISEC)	TERMINATE PER CHARA (MILLISEC)
TOS	0.200	0.0	0.200	0.0	0.200	0.0	0.200	0.0	0.200	0.0
[illegible]	0.200	0.0	0.200	0.0	0.200	9.200	NOT DONE	NOT DONE	0.200	0.0

EXHIBIT B-1: PROGRAM INPUTS

(Continued)

```
**************************************************
*****                                        *****
*****       ROUTE CROSS MESSAGE DATA         *****
*****                                        *****
**************************************************
```

** USER GENERATED MESSAGES **

BRIGADE	MESSAGE TYPE	INITIATION RATE (MSG/HOUR)
BDE1	ESD.I	34
BDE1	EOB.I	3
BDE1	ICM.I	4
BDE1	TER.I	4
BDE1	SDL.I	0
BDE1	NAI.I	6
BDE1	SWF.I	3
BDE1	PLM.I	1
BDE1	UTO.I	3
BDE1	UTD.I	13
BDE1	BIR.I	20
BDE1	RELA.I	0
BDE1	QERY.I	5
BDE2	ESD.I	12
BDE2	EOB.I	1
BDE2	ICM.I	1
BDE2	TER.I	1
BDE2	SDL.I	0
BDE2	NAI.I	2
BDE2	SWF.I	1
BDE2	PLM.I	0
BDE2	UTO.I	1
BDE2	UTD.I	6
BDE2	BIR.I	10
BDE2	RELA.I	0
BDE2	QERY.I	5
BDE3	ESD.I	5
BDE3	EOB.I	0
BDE3	ICM.I	0
BDE3	TER.I	1
BDE3	SDL.I	0
BDE3	NAI.I	1
BDE3	SWF.I	1
BDE3	PLM.I	0
BDE3	UTO.I	1
BDE3	UTD.I	3
BDE3	BIR.I	5
BDE3	RELA.I	0
BDE3	QERY.I	5

EXHIBIT B-1: PROGRAM INPUTS

(Continued)

BATTALION	PARENT BRIGADE	MESSAGE TYPE	INITIATION RATE (MSG/HOUR)	PROB OF DELETION AT BDE	PROB OF ALTERATION AT BDE
3N1.1	BDE1	ESD.I	3	0.0	0.0
3N1.1	BDE1	EOB.I	1	0.0	0.0
3N1.1	BDE1	ICM.I	1	0.0	0.0
3N1.1	BDE1	TER.I	1	0.0	0.0
3N1.1	BDE1	SDL.I	0	0.0	0.0
3N1.1	BDE1	NAI.I	1	0.0	0.0
3N1.1	BDE1	SWF.I	0	0.0	0.0
3N1.1	BDE1	PLM.I	0	0.0	0.0
3N1.1	BDE1	UTO.I	0	0.0	0.0
3N1.1	BDE1	UTD.I	1	0.0	0.0
3N1.1	BDE1	BIR.I	4	0.0	0.0
3N1.1	BDE1	RELA.I	0	0.0	0.0
3N1.1	BDE1	QERY.I	1	0.0	0.0
3N1.2	BDE1	ESD.I	3	0.0	0.0
3N1.2	BDE1	EOB.I	1	0.0	0.0
3N1.2	BDE1	ICM.I	1	0.0	0.0
3N1.2	BDE1	TER.I	1	0.0	0.0
3N1.2	BDE1	SDL.I	0	0.0	0.0
3N1.2	BDE1	NAI.I	1	0.0	0.0
3N1.2	BDE1	SWF.I	0	0.0	0.0
3N1.2	BDE1	PLM.I	0	0.0	0.0
3N1.2	BDE1	UTO.I	0	0.0	0.0
3N1.2	BDE1	UTD.I	1	0.0	0.0
3N1.2	BDE1	BIR.I	4	0.0	0.0
3N1.2	BDE1	RELA.I	0	0.0	0.0
3N1.2	BDE1	QERY.I	1	0.0	0.0
3N1.3	BDE1	ESD.I	3	0.0	0.0
3N1.3	BDE1	EOB.I	1	0.0	0.0
3N1.3	BDE1	ICM.I	1	0.0	0.0
3N1.3	BDE1	TER.I	1	0.0	0.0
3N1.3	BDE1	SDL.I	0	0.0	0.0
3N1.3	BDE1	NAI.I	1	0.0	0.0
3N1.3	BDE1	SWF.I	0	0.0	0.0
3N1.3	BDE1	PLM.I	0	0.0	0.0
3N1.3	BDE1	UTO.I	0	0.0	0.0
3N1.3	BDE1	UTD.I	1	0.0	0.0
3N1.3	BDE1	BIR.I	4	0.0	0.0
3N1.3	BDE1	RELA.I	0	0.0	0.0
3N1.3	BDE1	QERY.I	0	0.0	0.0
3N1.4	BDE1	ESD.I	5	0.0	0.0
3N1.4	BDE1	EOB.I	0	0.0	0.0
3N1.4	BDE1	ICM.I	1	0.0	0.0
3N1.4	BDE1	TER.I	0	0.0	0.0
3N1.4	BDE1	SDL.I	0	0.0	0.0
3N1.4	BDE1	NAI.I	1	0.0	0.0
3N1.4	BDE1	SWF.I	0	0.0	0.0
3N1.4	BDE1	PLM.I	0	0.0	0.0
3N1.4	BDE1	UTO.I	0	0.0	0.0
3N1.4	BDE1	UTD.I	1	0.0	0.0
3N1.4	BDE1	BIR.I	4	0.0	0.0
3N1.4	BDE1	RELA.I	0	0.0	0.0
3N1.4	BDE1	QERY.I	0	0.0	0.0
3N1.5	BDE1	ESD.I	2	0.0	0.0
3N1.5	BDE1	EOB.I	0	0.0	0.0
3N1.5	BDE1	ICM.I	0	0.0	0.0
3N1.5	BDE1	TER.I	[illegible]	0.0	0.0
3N1.5	BDE1	SDL.I	[illegible]	0.0	0.0
3N1.5	BDE1	NAI.I	1	0.0	0.0
3N1.5	BDE1	SWF.I	1	0.0	0.0
3N1.5	BDE1	PLM.I	0	0.0	0.0
3N1.5	BDE1	UTO.I	0	0.0	0.0
3N1.5	BDE1	UTD.I	1	0.0	0.0
3N1.5	BDE1	BIR.I	4	0.0	0.0
3N1.5	BDE1	RELA.I	0	0.0	0.0
3N1.5	BDE1	QERY.I	0	0.0	0.0

EXHIBIT B-1: PROGRAM INPUTS

(Continued)

3N2.1	3DE2	ESD.I	2	0.0	0.0
3N2.1	3DE2	EOB.I	0	0.0	0.0
3N2.1	3DE2	ICM.I	0	0.0	0.0
3N2.1	3DE2	TER.I	0	0.0	0.0
3N2.1	3DE2	SDL.I	0	0.0	0.0
3N2.1	3DE2	NAI.I	0	0.0	0.0
3N2.1	3DE2	SWF.I	0	0.0	0.0
3N2.1	3DE2	PLM.I	0	0.0	0.0
3N2.1	3DE2	UTO.I	0	0.0	0.0
3N2.1	3DE2	UTD.I	1	0.0	0.0
3N2.1	3DE2	BIR.I	2	0.0	0.0
3N2.1	3DE2	RELA.I	0	0.0	0.0
3N2.1	3DE2	QERY.I	1	0.0	0.0
3N2.2	3DE2	ESD.I	1	0.0	0.0
3N2.2	3DE2	EOB.I	0	0.0	0.0
3N2.2	3DE2	ICM.I	0	0.0	0.0
3N2.2	3DE2	TER.I	0	0.0	0.0
3N2.2	3DE2	SDL.I	0	0.0	0.0
3N2.2	3DE2	NAI.I	0	0.0	0.0
3N2.2	3DE2	SWF.I	0	0.0	0.0
3N2.2	3DE2	PLM.I	0	0.0	0.0
3N2.2	3DE2	UTO.I	0	0.0	0.0
3N2.2	3DE2	UTD.I	1	0.0	0.0
3N2.2	3DE2	BIR.I	2	0.0	0.0
3N2.2	3DE2	RELA.I	0	0.0	0.0
3N2.2	3DE2	QERY.I	1	0.0	0.0
3N2.3	3DE2	ESD.I	1	0.0	0.0
3N2.3	3DE2	EOB.I	0	0.0	0.0
3N2.3	3DE2	ICM.I	0	0.0	0.0
3N2.3	3DE2	TER.I	0	0.0	0.0
3N2.3	3DE2	SDL.I	0	0.0	0.0
3N2.3	3DE2	NAI.I	0	0.0	0.0
3N2.3	3DE2	SWF.I	0	0.0	0.0
3N2.3	3DE2	PLM.I	0	0.0	0.0
3N2.3	3DE2	UTO.I	0	0.0	0.0
3N2.3	3DE2	UTD.I	1	0.0	0.0
3N2.3	3DE2	BIR.I	2	0.0	0.0
3N2.3	3DE2	RELA.I	0	0.0	0.0
3N2.3	3DE2	QERY.I	0	0.0	0.0
3N2.4	3DE2	ESD.I	5	0.0	0.0
3N2.4	3DE2	EOB.I	1	0.0	0.0
3N2.4	3DE2	ICM.I	1	0.0	0.0
3N2.4	3DE2	TER.I	1	0.0	0.0
3N2.4	3DE2	SDL.I	0	0.0	0.0
3N2.4	3DE2	NAI.I	1	0.0	0.0
3N2.4	3DE2	SWF.I	0	0.0	0.0
3N2.4	3DE2	PLM.I	0	0.0	0.0
3N2.4	3DE2	UTO.I	0	0.0	0.0
3N2.4	3DE2	UTD.I	1	0.0	0.0
3N2.4	3DE2	BIR.I	2	0.0	0.0
3N2.4	3DE2	RELA.I	0	0.0	0.0
3N2.4	3DE2	QERY.I	0	0.0	0.0
3N2.5	3DE2	ESD.I	1	0.0	0.0
3N2.5	3DE2	EOB.I	0	0.0	0.0
3N2.5	3DE2	ICM.I	0	0.0	0.0
3N2.5	3DE2	TER.I	0	0.0	0.0
3N2.5	3DE2	SDL.I	0	0.0	0.0
3N2.5	3DE2	NAI.I	0	0.0	0.0
3N2.5	3DE2	SWF.I	0	0.0	0.0
3N2.5	3DE2	PLM.I	0	0.0	0.0
3N2.5	3DE2	UTO.I	0	0.0	0.0
3N2.5	3DE2	UTD.I	1	0.0	0.0
3N2.5	3DE2	BIR.I	2	0.0	0.0
3N2.5	3DE2	RELA.I	0	0.0	0.0
3N2.5	3DE2	QERY.I	0	0.0	0.0

EXHIBIT B-1: PROGRAM INPUTS

(Continued)

3N3.1	3DE3	ESD.I	1	0.0	0.0
3N3.1	3DE3	EOB.I	0	0.0	0.0
3N3.1	3DE3	ICM.I	0	0.0	0.0
3N3.1	3DE3	TER.I	0	0.0	0.0
3N3.1	3DE3	SDL.I	0	0.0	0.0
3N3.1	3DE3	NAI.I	0	0.0	0.0
3N3.1	3DE3	SWF.I	0	0.0	0.0
3N3.1	3DE3	PLM.I	0	0.0	0.0
3N3.1	3DE3	UTO.I	0	0.0	0.0
3N3.1	3DE3	UTD.I	0	0.0	0.0
3N3.1	3DE3	BIR.I	1	0.0	0.0
3N3.1	3DE3	RELA.I	0	0.0	0.0
3N3.1	3DE3	QERY.I	1	0.0	0.0
3N3.2	3DE3	ESD.I	1	0.0	0.0
3N3.2	3DE3	EOB.I	0	0.0	0.0
3N3.2	3DE3	ICM.I	0	0.0	0.0
3N3.2	3DE3	TER.I	0	0.0	0.0
3N3.2	3DE3	SDL.I	0	0.0	0.0
3N3.2	3DE3	NAI.I	0	0.0	0.0
3N3.2	3DE3	SWF.I	0	0.0	0.0
3N3.2	3DE3	PLM.I	0	0.0	0.0
3N3.2	3DE3	UTO.I	0	0.0	0.0
3N3.2	3DE3	UTD.I	0	0.0	0.0
3N3.2	3DE3	BIR.I	1	0.0	0.0
3N3.2	3DE3	RELA.I	0	0.0	0.0
3N3.2	3DE3	QERY.I	1	0.0	0.0
3N3.3	3DE3	ESD.I	1	0.0	0.0
3N3.3	3DE3	EOB.I	0	0.0	0.0
3N3.3	3DE3	ICM.I	0	0.0	0.0
3N3.3	3DE3	TER.I	0	0.0	0.0
3N3.3	3DE3	SDL.I	0	0.0	0.0
3N3.3	3DE3	NAI.I	0	0.0	0.0
3N3.3	3DE3	SWF.I	0	0.0	0.0
3N3.3	3DE3	PLM.I	0	0.0	0.0
3N3.3	3DE3	UTO.I	0	0.0	0.0
3N3.3	3DE3	UTD.I	0	0.0	0.0
3N3.3	3DE3	BIR.I	1	0.0	0.0
3N3.3	3DE3	RELA.I	0	0.0	0.0
3N3.3	3DE3	QERY.I	0	0.0	0.0
3N3.4	3DE3	ESD.I	1	0.0	0.0
3N3.4	3DE3	EOB.I	0	0.0	0.0
3N3.4	3DE3	ICM.I	0	0.0	0.0
3N3.4	3DE3	TER.I	0	0.0	0.0
3N3.4	3DE3	SDL.I	0	0.0	0.0
3N3.4	3DE3	NAI.I	0	0.0	0.0
3N3.4	3DE3	SWF.I	0	0.0	0.0
3N3.4	3DE3	PLM.I	0	0.0	0.0
3N3.4	3DE3	UTO.I	0	0.0	0.0
3N3.4	3DE3	UTD.I	1	0.0	0.0
3N3.4	3DE3	BIR.I	1	0.0	0.0
3N3.4	3DE3	RELA.I	0	0.0	0.0
3N3.4	3DE3	QERY.I	0	0.0	0.0
3N3.5	3DE3	ESD.I	0	0.0	0.0
3N3.5	3DE3	EOB.I	0	0.0	0.0
3N3.5	3DE3	ICM.I	0	0.0	0.0
3N3.5	3DE3	TER.I	0	0.0	0.0
3N3.5	3DE3	SDL.I	0	0.0	0.0
3N3.5	3DE3	NAI.I	0	0.0	0.0
3N3.5	3DE3	SWF.I	0	0.0	0.0
3N3.5	3DE3	PLM.I	0	0.0	0.0
3N3.5	3DE3	UTO.I	0	0.0	0.0
3N3.5	3DE3	UTD.I	1	0.0	0.0
3N3.5	3DE3	BIR.I	1	0.0	0.0
3N3.5	3DE3	RELA.I	0	0.0	0.0
3N3.5	3DE3	QERY.I	0	0.0	0.0

EXHIBIT B-1: PROGRAM INPUTS

(Continued)

OTHER USERS	MESSAGE TYPE	INITIATION RATE (MSG/HOUR)
TAC CP	ESD.I	11
TAC CP	EOB.I	2
TAC CP	ICM.I	1
TAC CP	TER.I	0
TAC CP	SDL.I	0
TAC CP	NAI.I	2
TAC CP	SWF.I	3
TAC CP	PLM.I	0
TAC CP	UTO.I	4
TAC CP	UTD.I	15
TAC CP	BIR.I	0
TAC CP	RELA.I	1
TAC CP	QERY.I	10
DIV ARTY	ESD.I	7
DIV ARTY	EOB.I	0
DIV ARTY	ICM.I	3
DIV ARTY	TER.I	0
DIV ARTY	SDL.I	0
DIV ARTY	NAI.I	0
DIV ARTY	SWF.I	1
DIV ARTY	PLM.I	0
DIV ARTY	UTO.I	2
DIV ARTY	UTD.I	8
DIV ARTY	BIR.I	8
DIV ARTY	RELA.I	0
DIV ARTY	QERY.I	1
ENG BN	ESD.I	9
ENG BN	EOB.I	0
ENG BN	ICM.I	1
ENG BN	TER.I	5
ENG BN	SDL.I	0
ENG BN	NAI.I	2
ENG BN	SWF.I	0
ENG BN	PLM.I	0
ENG BN	UTO.I	0
ENG BN	UTD.I	1
ENG BN	BIR.I	5
ENG BN	RELA.I	0
ENG BN	QERY.I	2

EXHIBIT B-1: PROGRAM INPUTS

(Continued)

ADA BN	ESD.I	4
ADA BN	EOB.I	0
ADA BN	ICM.I	1
ADA BN	TER.I	0
ADA BN	SDL.I	0
ADA BN	NAI.I	0
ADA BN	SWF.I	0
ADA BN	PLM.I	0
ADA BN	UTO.I	0
ADA BN	UTD.I	1
ADA BN	BIR.I	2
ADA BN	RELA.I	0
ADA BN	QERY.I	1
AVN BN	ESD.I	11
AVN BN	EOB.I	0
AVN BN	ICM.I	1
AVN BN	TER.I	2
AVN BN	SDL.I	0
AVN BN	NAI.I	1
AVN BN	SWF.I	0
AVN BN	PLM.I	0
AVN BN	UTO.I	0
AVN BN	UTD.I	1
AVN BN	BIR.I	2
AVN BN	RELA.I	0
AVN BN	QERY.I	2
CEWI BN	ESD.I	23
CEWI BN	EOB.I	3
CEWI BN	ICM.I	3
CEWI BN	TER.I	4
CEWI BN	SDL.I	0
CEWI BN	NAI.I	1
CEWI BN	SWF.I	0
CEWI BN	PLM.I	1
CEWI BN	UTO.I	1
CEWI BN	UTD.I	1
CEWI BN	BIR.I	1
CEWI BN	RELA.I	1
CEWI BN	QERY.I	2

EXHIBIT B-1: PROGRAM INPUTS

(Continued)

CAV SQN	ESD.I	23
CAV SQN	EOB.I	3
CAV SQN	ICM.I	3
CAV SQN	TER.I	3
CAV SQN	SDL.I	0
CAV SQN	NAI.I	1
CAV SQN	SWF.I	0
CAV SQN	PLM.I	0
CAV SQN	UTO.I	1
CAV SQN	UTD.I	5
CAV SQN	BIR.I	20
CAV SQN	RELA.I	0
CAV SQN	QERY.I	2
DISCOM	ESD.I	0
DISCOM	EOB.I	0
DISCOM	ICM.I	0
DISCOM	TER.I	0
DISCOM	SDL.I	0
DISCOM	NAI.I	0
DISCOM	SWF.I	0
DISCOM	PLM.I	0
DISCOM	UTO.I	1
DISCOM	UTD.I	1
DISCOM	BIR.I	0
DISCOM	RELA.I	0
DISCOM	QERY.I	2
INTEL EL	ESD.I	15
INTEL EL	EOB.I	3
INTEL EL	ICM.I	6
INTEL EL	TER.I	0
INTEL EL	SDL.I	1
INTEL EL	NAI.I	0
INTEL EL	SWF.I	1
INTEL EL	PLM.I	2
INTEL EL	UTO.I	1
INTEL EL	UTD.I	2
INTEL EL	BIR.I	5
INTEL EL	RELA.I	0
INTEL EL	QERY.I	10

EXHIBIT B-1: PROGRAM INPUTS

(Continued)

OPS EL	ESD.I	2
OPS EL	EOB.I	2
OPS EL	ICM.I	5
OPS EL	TER.I	0
OPS EL	SDL.I	0
OPS EL	NAI.I	3
OPS EL	SWF.I	4
OPS EL	PLM.I	1
OPS EL	UTO.I	4
OPS EL	UTD.I	15
OPS EL	BIR.I	0
OPS EL	RELA.I	0
OPS EL	QERY.I	1
TACFIRE	ESD.I	3
TACFIRE	EOB.I	0
TACFIRE	ICM.I	0
TACFIRE	TER.I	0
TACFIRE	SDL.I	0
TACFIRE	NAI.I	0
TACFIRE	SWF.I	0
TACFIRE	PLM.I	0
TACFIRE	UTO.I	0
TACFIRE	UTD.I	0
TACFIRE	BIR.I	0
TACFIRE	RELA.I	0
TACFIRE	QERY.I	10
ADJ DIVS	ESD.I	3
ADJ DIVS	EOB.I	1
ADJ DIVS	ICM.I	0
ADJ DIVS	TER.I	0
ADJ DIVS	SDL.I	0
ADJ DIVS	NAI.I	0
ADJ DIVS	SWF.I	0
ADJ DIVS	PLM.I	0
ADJ DIVS	UTO.I	0
ADJ DIVS	UTD.I	0
ADJ DIVS	BIR.I	2
ADJ DIVS	RELA.I	0
ADJ DIVS	QERY.I	10

EXHIBIT B-1: PROGRAM INPUTS

(Continued)

NATO	ESD.I	5
NATO	EOB.I	0
NATO	ICM.I	0
NATO	TER.I	0
NATO	SDL.I	0
NATO	NAI.I	0
NATO	SWF.I	0
NATO	PLM.I	0
NATO	UTO.I	0
NATO	UTD.I	0
NATO	BIR.I	1
NATO	RELA.I	0
NATO	QERY.I	0

** TOS GENERATED MESSAGES **

TERMINUS	MESSAGE TYPE	OUTPUT RATIO A	OUTPUT RATIO B
BDE1	ESD.O	0.0	0.557
BDE1	EOB.O	0.0	0.368
BDE1	ICM.O	0.0	0.233
BDE1	TER.O	0.0	2.220
BDE1	SDL.O	0.0	0.0
BDE1	NAI.O	0.0	0.0
BDE1	SWF.O	0.0	1.160
BDE1	PLM.O	0.0	0.0
BDE1	UTO.O	0.0	0.0
BDE1	UTD.O	0.0	0.657
BDE1	BIR.O	0.0	0.0
BDE1	RELA.O	0.0	3.490
BDE1	QERY.O	1.000	0.0
BDE2	ESD.O	0.0	0.282
BDE2	EOB.O	0.0	0.155
BDE2	ICM.O	0.0	0.099
BDE2	TER.O	0.0	1.360
BDE2	SDL.O	0.0	0.0
BDE2	NAI.O	0.0	0.0
BDE2	SWF.O	0.0	0.699
BDE2	PLM.O	0.0	0.0
BDE2	UTO.O	0.0	0.0
BDE2	UTD.O	0.0	0.835
BDE2	BIR.O	0.0	0.0
BDE2	RELA.O	0.0	2.440
BDE2	QERY.O	1.000	0.0

EXHIBIT B-1: PROGRAM INPUTS

(Continued)

BDE3	ESD.0	0.0	0.049
BDE3	EOB.0	0.0	0.0
BDE3	ICM.0	0.0	0.0
BDE3	TER.0	0.0	0.656
BDE3	SDL.0	0.0	0.0
BDE3	NAI.0	0.0	0.0
BDE3	SWF.0	0.0	0.225
BDE3	PLM.0	0.0	0.0
BDE3	UTO.0	0.0	0.875
BDE3	UTD.0	0.0	0.582
BDE3	BIR.0	0.0	0.0
BDE3	RELA.0	0.0	2.360
BDE3	QERY.0	1.000	0.0
BN1.1	ESD.0	0.0	0.045
BN1.1	EOB.0	0.0	0.105
BN1.1	ICM.0	0.0	0.067
BN1.1	TER.0	0.0	0.183
BN1.1	SDL.0	0.0	0.0
BN1.1	NAI.0	0.0	0.0
BN1.1	SWF.0	0.0	0.0
BN1.1	PLM.0	0.0	0.0
BN1.1	UTO.0	0.0	0.0
BN1.1	UTD.0	0.0	0.053
BN1.1	BIR.0	0.0	0.0
BN1.1	RELA.0	0.0	0.0
BN1.1	QERY.0	1.000	0.0
BN1.2	ESD.0	0.0	0.045
BN1.2	EOB.0	0.0	0.105
BN1.2	ICM.0	0.0	0.067
BN1.2	TER.0	0.0	0.183
BN1.2	SDL.0	0.0	0.0
BN1.2	NAI.0	0.0	0.0
BN1.2	SWF.0	0.0	0.0
BN1.2	PLM.0	0.0	0.0
BN1.2	UTO.0	0.0	0.0
BN1.2	UTD.0	0.0	0.053
BN1.2	BIR.0	0.0	0.0
BN1.2	RELA.0	0.0	0.0
BN1.2	QERY.0	1.000	0.0

EXHIBIT B-1: PROGRAM INPUTS

(Continued)

BN1.3	ESD.0	0.0	0.045
BN1.3	EOB.0	0.0	0.105
BN1.3	ICM.0	0.0	0.067
BN1.3	TER.0	0.0	0.183
BN1.3	SDL.0	0.0	0.0
BN1.3	NAI.0	0.0	0.0
BN1.3	SWF.0	0.0	0.0
BN1.3	PLM.0	0.0	0.0
BN1.3	UTO.0	0.0	0.0
BN1.3	UTD.0	0.0	0.053
BN1.3	BIR.0	0.0	0.0
BN1.3	RELA.0	0.0	0.0
BN1.3	QERY.0	1.000	0.0
BN1.4	ESD.0	0.0	0.060
BN1.4	EOB.0	0.0	0.0
BN1.4	ICM.0	0.0	0.0
BN1.4	TER.0	0.0	0.152
BN1.4	SDL.0	0.0	0.0
BN1.4	NAI.0	0.0	0.0
BN1.4	SWF.0	0.0	0.0
BN1.4	PLM.0	0.0	0.0
BN1.4	UTO.0	0.0	0.0
BN1.4	UTD.0	0.0	0.046
BN1.4	BIR.0	0.0	0.0
BN1.4	RELA.0	0.0	0.0
BN1.4	QERY.0	1.000	0.0
BN1.5	ESD.0	0.0	0.032
BN1.5	EOB.0	0.0	0.0
BN1.5	ICM.0	0.0	0.0
BN1.5	TER.0	0.0	0.176
BN1.5	SDL.0	0.0	0.0
BN1.5	NAI.0	0.0	0.0
BN1.5	SWF.0	0.0	0.302
BN1.5	PLM.0	0.0	0.0
BN1.5	UTO.0	0.0	0.0
BN1.5	UTD.0	0.0	0.051
BN1.5	BIR.0	0.0	0.0
BN1.5	RELA.0	0.0	0.0
BN1.5	QERY.0	1.000	0.0

EXHIBIT B-1: PROGRAM INPUTS

(Continued)

BN2.1	ESD.0	0.0	0.051
BN2.1	EOB.0	0.0	0.0
BN2.1	ICM.0	0.0	0.0
BN2.1	TER.0	0.0	0.133
BN2.1	SDL.0	0.0	0.0
BN2.1	NAI.0	0.0	0.0
BN2.1	SWF.0	0.0	0.0
BN2.1	PLM.0	0.0	0.0
BN2.1	UTO.0	0.0	0.0
BN2.1	UTD.0	0.0	0.120
BN2.1	BIR.0	0.0	0.0
BN2.1	RELA.0	0.0	0.0
BN2.1	QERY.0	1.000	0.0
BN2.2	ESD.0	0.0	0.025
BN2.2	EOB.0	0.0	0.0
BN2.2	ICM.0	0.0	0.0
BN2.2	TER.0	0.0	0.131
BN2.2	SDL.0	0.0	0.0
BN2.2	NAI.0	0.0	0.0
BN2.2	SWF.0	0.0	0.0
BN2.2	PLM.0	0.0	0.0
BN2.2	UTO.0	0.0	0.0
BN2.2	UTD.0	0.0	0.118
BN2.2	BIR.0	0.0	0.0
BN2.2	RELA.0	0.0	0.0
BN2.2	QERY.0	1.000	0.0
BN2.3	ESD.0	0.0	0.025
BN2.3	EOB.0	0.0	0.0
BN2.3	ICM.0	0.0	0.0
BN2.3	TER.0	0.0	0.131
BN2.3	SDL.0	0.0	0.0
BN2.3	NAI.0	0.0	0.0
BN2.3	SWF.0	0.0	0.0
BN2.3	PLM.0	0.0	0.0
BN2.3	UTO.0	0.0	0.0
BN2.3	UTD.0	0.0	0.118
BN2.3	BIR.0	0.0	0.0
BN2.3	RELA.0	0.0	0.0
BN2.3	QERY.0	1.000	0.0

EXHIBIT B-1: PROGRAM INPUTS

(Continued)

BN2.4	ESD.0	0.0	0.058
BN2.4	EOB.0	0.0	0.067
BN2.4	ICM.0	0.0	0.042
BN2.4	TER.0	0.0	0.234
BN2.4	SDL.0	0.0	0.0
BN2.4	NAI.0	0.0	0.0
BN2.4	SWF.0	0.0	0.0
BN2.4	PLM.0	0.0	0.0
BN2.4	UTO.0	0.0	0.0
BN2.4	UTD.0	0.0	0.101
BN2.4	BIR.0	0.0	0.0
BN2.4	RELA.0	0.0	0.0
BN2.4	QERY.0	1.000	0.0
BN2.5	ESD.0	0.0	0.022
BN2.5	EOB.0	0.0	0.0
BN2.5	ICM.0	0.0	0.0
BN2.5	TER.0	0.0	0.235
BN2.5	SDL.0	0.0	0.0
BN2.5	NAI.0	0.0	0.0
BN2.5	SWF.0	0.0	0.0
BN2.5	PLM.0	0.0	0.0
BN2.5	UTO.0	0.0	0.0
BN2.5	UTD.0	0.0	0.106
BN2.5	BIR.0	0.0	0.0
BN2.5	RELA.0	0.0	0.0
BN2.5	QERY.0	1.000	0.0
BN3.1	ESD.0	0.0	0.005
BN3.1	EOB.0	0.0	0.0
BN3.1	ICM.0	0.0	0.0
BN3.1	TER.0	0.0	0.040
BN3.1	SDL.0	0.0	0.0
BN3.1	NAI.0	0.0	0.0
BN3.1	SWF.0	0.0	0.0
BN3.1	PLM.0	0.0	0.0
BN3.1	UTO.0	0.0	0.053
BN3.1	UTD.0	0.0	0.048
BN3.1	BIR.0	0.0	0.0
BN3.1	RELA.0	0.0	0.0
BN3.1	QERY.0	1.000	0.0

EXHIBIT B-1: PROGRAM INPUTS

(Continued)

BN3.2	ESD.0	0.0	0.005
BN3.2	EOB.0	0.0	0.0
BN3.2	ICM.0	0.0	0.0
BN3.2	TER.0	0.0	0.040
BN3.2	SDL.0	0.0	0.0
BN3.2	NAI.0	0.0	0.0
BN3.2	SWF.0	0.0	0.0
BN3.2	PLM.0	0.0	0.0
BN3.2	UTO.0	0.0	0.053
BN3.2	UTD.0	0.0	0.048
BN3.2	BIR.0	0.0	0.0
BN3.2	RELA.0	0.0	0.0
BN3.2	QERY.0	1.000	0.0
BN3.3	ESD.0	0.0	0.005
BN3.3	EOB.0	0.0	0.0
BN3.3	ICM.0	0.0	0.0
BN3.3	TER.0	0.0	0.040
BN3.3	SDL.0	0.0	0.0
BN3.3	NAI.0	0.0	0.0
BN3.3	SWF.0	0.0	0.0
BN3.3	PLM.0	0.0	0.0
BN3.3	UTO.0	0.0	0.053
BN3.3	UTD.0	0.0	0.048
BN3.3	BIR.0	0.0	0.0
BN3.3	RELA.0	0.0	0.0
BN3.3	QERY.0	1.000	0.0
BN3.4	ESD.0	0.0	0.005
BN3.4	EOB.0	0.0	0.0
BN3.4	ICM.0	0.0	0.0
BN3.4	TER.0	0.0	0.040
BN3.4	SDL.0	0.0	0.0
BN3.4	NAI.0	0.0	0.0
BN3.4	SWF.0	0.0	0.0
BN3.4	PLM.0	0.0	0.0
BN3.4	UTO.0	0.0	0.053
BN3.4	UTD.0	0.0	0.048
BN3.4	BIR.0	0.0	0.0
BN3.4	RELA.0	0.0	0.0
BN3.4	QERY.0	1.000	0.0

EXHIBIT B-1: PROGRAM INPUTS

(Continued)

BN3.5	ESD.0	0.0	0.005
BN3.5	EOB.0	0.0	0.0
BN3.5	ICM.0	0.0	0.0
BN3.5	TER.0	0.0	0.040
BN3.5	SDL.0	0.0	0.0
BN3.5	NAI.0	0.0	0.0
BN3.5	SWF.0	0.0	0.0
BN3.5	PLM.0	0.0	0.0
BN3.5	UTO.0	0.0	0.053
BN3.5	UTD.0	0.0	0.048
BN3.5	BIR.0	0.0	0.0
BN3.5	RELA.0	0.0	0.0
BN3.5	QERY.0	1.000	0.0
TAC CP	ESD.0	0.0	0.387
TAC CP	EOB.0	0.0	0.316
TAC CP	ICM.0	0.0	0.153
TAC CP	TER.0	0.0	1.520
TAC CP	SDL.0	0.0	0.0
TAC CP	NAI.0	0.0	0.110
TAC CP	SWF.0	0.0	0.632
TAC CP	PLM.0	0.0	0.0
TAC CP	UTO.0	0.0	0.843
TAC CP	UTD.0	0.0	0.916
TAC CP	BIR.0	0.0	0.323
TAC CP	RELA.0	0.0	3.790
TAC CP	QERY.0	1.000	0.0
DIV ARTY	ESD.0	0.0	0.188
DIV ARTY	EOB.0	0.0	0.141
DIV ARTY	ICM.0	0.0	0.0
DIV ARTY	TER.0	0.0	0.622
DIV ARTY	SDL.0	0.0	0.0
DIV ARTY	NAI.0	0.0	0.0
DIV ARTY	SWF.0	0.0	0.667
DIV ARTY	PLM.0	0.0	0.0
DIV ARTY	UTO.0	0.0	0.915
DIV ARTY	UTD.0	0.0	0.614
DIV ARTY	BIR.0	0.0	0.0
DIV ARTY	RELA.0	0.0	0.0
DIV ARTY	QERY.0	1.000	0.0

EXHIBIT B-1: PROGRAM INPUTS

(Continued)

ENG BN	ESD.0	0.0	0.143
ENG BN	EOB.0	0.0	0.0
ENG BN	ICM.0	0.0	0.081
ENG BN	TER.0	0.0	0.268
ENG BN	SDL.0	0.0	0.0
ENG BN	NAI.0	0.0	0.0
ENG BN	SWF.0	0.0	0.357
ENG BN	PLM.0	0.0	0.0
ENG BN	UTO.0	0.0	0.282
ENG BN	UTD.0	0.0	0.161
ENG BN	BIR.0	0.0	0.0
ENG BN	RELA.0	0.0	0.0
ENG BN	QERY.0	1.000	0.0
ADA BN	ESD.0	0.0	0.093
ADA BN	EOB.0	0.0	0.0
ADA BN	ICM.0	0.0	0.0
ADA BN	TER.0	0.0	0.240
ADA BN	SDL.0	0.0	0.0
ADA BN	NAI.0	0.0	0.0
ADA BN	SWF.0	0.0	0.399
ADA BN	PLM.0	0.0	0.0
ADA BN	UTO.0	0.0	0.0
ADA BN	UTD.0	0.0	0.0
ADA BN	BIR.0	0.0	0.0
ADA BN	RELA.0	0.0	0.0
ADA BN	QERY.0	1.000	0.0
AVN BN	ESD.0	0.0	0.133
AVN BN	EOB.0	0.0	0.0
AVN BN	ICM.0	0.0	0.058
AVN BN	TER.0	0.0	0.830
AVN BN	SDL.0	0.0	0.0
AVN BN	NAI.0	0.0	0.0
AVN BN	SWF.0	0.0	0.254
AVN BN	PLM.0	0.0	0.0
AVN BN	UTO.0	0.0	0.200
AVN BN	UTD.0	0.0	0.115
AVN BN	BIR.0	0.0	0.0
AVN BN	RELA.0	0.0	0.0
AVN BN	QERY.0	1.000	0.0

EXHIBIT B-1: PROGRAM INPUTS

(Continued)

CEWI BN	ESD.0	0.0	0.214
CEWI BN	EOB.0	0.0	0.163
CEWI BN	ICM.0	0.0	0.200
CEWI BN	TER.0	0.0	0.0
CEWI BN	SDL.0	0.0	0.0
CEWI BN	NAI.0	0.0	0.0
CEWI BN	SWF.0	0.0	0.413
CEWI BN	PLM.0	0.0	0.0
CEWI BN	UTO.0	0.0	0.345
CEWI BN	UTD.0	0.0	0.0
CEWI BN	BIR.0	0.0	0.0
CEWI BN	RELA.0	0.0	0.0
CEWI BN	QERY.0	1.000	0.0
CAV SQN	ESD.0	0.0	0.437
CAV SQN	EOB.0	0.0	0.186
CAV SQN	ICM.0	0.0	0.171
CAV SQN	TER.0	0.0	1.610
CAV SQN	SDL.0	0.0	0.0
CAV SQN	NAI.0	0.0	0.0
CAV SQN	SWF.0	0.0	0.708
CAV SQN	PLM.0	0.0	0.0
CAV SQN	UTO.0	0.0	0.0
CAV SQN	UTD.0	0.0	0.672
CAV SQN	BIR.0	0.0	0.0
CAV SQN	RELA.0	0.0	0.0
CAV SQN	QERY.0	1.000	0.0
DISCOM	ESD.0	0.0	0.013
DISCOM	EOB.0	0.0	0.0
DISCOM	ICM.0	0.0	0.0
DISCOM	TER.0	0.0	0.0
DISCOM	SDL.0	0.0	0.0
DISCOM	NAI.0	0.0	0.0
DISCOM	SWF.0	0.0	0.170
DISCOM	PLM.0	0.0	0.0
DISCOM	UTO.0	0.0	0.710
DISCOM	UTD.0	0.0	0.153
DISCOM	BIR.0	0.0	0.529
DISCOM	RELA.0	0.0	0.0
DISCOM	QERY.0	1.000	0.0

EXHIBIT B-1: PROGRAM INPUTS

(Continued)

INTEL EL	ESD.0	0.0	0.446
INTEL EL	EOB.0	0.0	0.682
INTEL EL	ICM.0	0.0	0.347
INTEL EL	TER.0	0.0	1.300
INTEL EL	SDL.0	0.0	0.0
INTEL EL	NAI.0	0.0	0.195
INTEL EL	SWF.0	0.0	0.695
INTEL EL	PLM.0	0.0	0.0
INTEL EL	UTO.0	0.0	0.0
INTEL EL	UTD.0	0.0	0.198
INTEL EL	BIR.0	0.0	0.0
INTEL EL	RELA.0	0.0	2.430
INTEL EL	QERY.0	1.000	0.0
OPS EL	ESD.0	0.0	0.245
OPS EL	EOB.0	0.0	0.150
OPS EL	ICM.0	0.0	0.154
OPS EL	TER.0	0.0	1.320
OPS EL	SDL.0	0.0	0.0
OPS EL	NAI.0	0.0	0.136
OPS EL	SWF.0	0.0	0.815
OPS EL	PLM.0	0.0	0.0
OPS EL	UTO.0	0.0	0.598
OPS EL	UTD.0	0.0	0.868
OPS EL	BIR.0	0.0	0.039
OPS EL	RELA.0	0.0	0.0
OPS EL	QERY.0	1.000	0.0
TACFIRE	ESD.0	0.0	0.049
TACFIRE	EOB.0	0.0	0.0
TACFIRE	ICM.0	0.0	0.0
TACFIRE	TER.0	0.0	0.151
TACFIRE	SDL.0	0.0	0.0
TACFIRE	NAI.0	0.0	0.0
TACFIRE	SWF.0	0.0	0.126
TACFIRE	PLM.0	0.0	0.0
TACFIRE	UTO.0	0.0	0.099
TACFIRE	UTD.0	0.0	0.0
TACFIRE	BIR.0	0.0	0.0
TACFIRE	RELA.0	0.0	0.0
TACFIRE	QERY.0	1.000	0.0

EXHIBIT B-1: PROGRAM INPUTS

(Continued)

ADJ DIVS	ESD.0	0.0	0.065
ADJ DIVS	EOB.0	0.0	0.0
ADJ DIVS	ICM.0	0.0	0.0
ADJ DIVS	TER.0	0.0	0.126
ADJ DIVS	SDL.0	0.0	0.0
ADJ DIVS	NAI.0	0.0	0.0
ADJ DIVS	SWF.0	0.0	0.0
ADJ DIVS	PLM.0	0.0	0.0
ADJ DIVS	UTO.0	0.0	0.0
ADJ DIVS	UTD.0	0.0	0.019
ADJ DIVS	BIR.0	0.0	0.0
ADJ DIVS	RELA.0	0.0	2.360
ADJ DIVS	QERY.0	1.000	0.0
NATO	ESD.0	0.0	0.130
NATO	EOB.0	0.0	0.0
NATO	ICM.0	0.0	0.0
NATO	TER.0	0.0	0.0
NATO	SDL.0	0.0	0.0
NATO	NAI.0	0.0	0.0
NATO	SWF.0	0.0	0.0
NATO	PLM.0	0.0	0.0
NATO	UTO.0	0.0	0.0
NATO	UTD.0	0.0	0.0
NATO	BIR.0	0.0	0.0
NATO	RELA.0	0.0	0.0
NATO	QERY.0	1.000	0.0

EXHIBIT B-1: PROGRAM INPUTS

(Concluded)

BIT ERROR RATES

SENDING NODE	RECEIVING NODE	ERROR RATE (BITS/1000)	SENDING NODE	RECEIVING NODE	ERROR RATE (BITS/1000)
BDE1	FEP	0.0	FEP	BDE1	0.0
BDE2	FEP	0.0	FEP	BDE2	0.0
BDE3	FEP	0.0	FEP	BDE3	0.0
BN1.1	BDE1	0.0	BDE1	BN1.1	0.0
BN1.2	BDE1	0.0	BDE1	BN1.2	0.0
BN1.3	BDE1	0.0	BDE1	BN1.3	0.0
BN1.4	BDE1	0.0	BDE1	BN1.4	0.0
BN1.5	BDE1	0.0	BDE1	BN1.5	0.0
BN2.1	BDE2	0.0	BDE2	BN2.1	0.0
BN2.2	BDE2	0.0	BDE2	BN2.2	0.0
BN2.3	BDE2	0.0	BDE2	BN2.3	0.0
BN2.4	BDE2	0.0	BDE2	BN2.4	0.0
BN2.5	BDE2	0.0	BDE2	BN2.5	0.0
BN3.1	BDE3	0.0	BDE3	BN3.1	0.0
BN3.2	BDE3	0.0	BDE3	BN3.2	0.0
BN3.3	BDE3	0.0	BDE3	BN3.3	0.0
BN3.4	BDE3	0.0	BDE3	BN3.4	0.0
BN3.5	BDE3	0.0	BDE3	BN3.5	0.0
TAC CP	FEP	0.0	FEP	TAC CP	0.0
DIV ARTY	FEP	0.0	FEP	DIV ARTY	0.0
ENG BN	FEP	0.0	FEP	ENG BN	0.0
ADA BN	FEP	0.0	FEP	ADA BN	0.0
AVN BN	FEP	0.0	FEP	AVN BN	0.0
CEWI BN	FEP	0.0	FEP	CEWI BN	0.0
CAV SQN	FEP	0.0	FEP	CAV SQN	0.0
DISCOM	FEP	0.0	FEP	DISCOM	0.0
INTEL EL	FEP	0.0	FEP	INTEL EL	0.0
OPS EL	FEP	0.0	FEP	OPS EL	0.0
TACFIRE	FEP	0.0	FEP	TACFIRE	0.0
ADJ DIVS	FEP	0.0	FEP	ADJ DIVS	0.0
NATO	FEP	0.0	FEP	NATO	0.0

EXHIBIT B-2: PROGRAM OUTPUTS

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*****************************************************
*******                                       *******
*******   TABLE 1:  ROUTE SUMMARY STATISTICS  *******
*******                                       *******
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ROUTE	EXPECTED DELAY (MIN.)	TRAFFIC RATE (MSG/HR.)	RANK
BN1.3	0.210	33.985	1.000
BN1.1	0.210	35.985	2.000
BN1.2	0.210	35.985	3.000
BN1.5	0.210	29.014	4.000
BN1.4	0.210	31.025	5.000
CAV SQN	0.207	247.000	6.000
BN2.3	0.184	21.969	7.000
BN2.2	0.184	23.969	8.000
BN2.5	0.184	23.063	9.000
BN2.1	0.184	30.288	10.000
BN2.4	0.184	40.009	11.000
BN3.5	0.181	9.001	12.000
BN3.3	0.181	8.997	13.000
BN3.1	0.181	10.997	14.000
BN3.2	0.181	10.997	15.000
BN3.4	0.181	10.000	16.000
NATO	0.153	30.960	17.000
DISCOM	0.008	97.954	18.000
DIV ARTY	0.008	156.929	19.000
ENG BN	0.007	86.003	20.000
AVN BN	0.007	84.890	21.000
BDE1	0.007	319.939	22.000
TACFIRE	0.007	40.001	23.000
ADA BN	0.007	39.992	24.000
ADJ DIVS	0.007	47.993	25.000
CEWI BN	0.007	101.938	26.000
TAC CP	0.007	330.771	27.000
BDE3	0.007	122.971	28.000
BDE2	0.007	216.117	29.000
OPS EL	0.007	211.560	30.000
INTEL EL	0.007	228.046	31.000

EXHIBIT B-2: PROGRAM OUTPUTS

(Continued)

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*******                                       *******
*******   TABLE 2:  MESSAGE SUMMARY STATISTICS  *******
*******                                       *******
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MESSAGE TYPE	EXPECTED DELAY (MIN.)	TRAFFIC RATE (MSG/HR.)	RANK
SDL.I	0.197	1.000	1.000
BIR.I	0.146	116.000	2.000
TER.I	0.105	25.000	3.000
RELA.I	0.092	2.000	4.000
EOB.I	0.084	22.000	5.000
ESD.I	0.081	196.999	6.000
ICM.I	0.069	34.000	7.000
NAI.I	0.063	25.000	8.000
UTD.O	0.054	523.127	9.000
UTD.I	0.052	84.000	10.000
ICM.O	0.049	53.572	11.000
EOB.O	0.048	50.272	12.000
SWF.I	0.047	15.000	13.000
ESD.O	0.045	706.028	14.000
TER.O	0.044	334.414	15.000
PLM.I	0.042	5.000	16.000
SWF.O	0.030	103.106	17.000
UTO.I	0.027	19.000	18.000
QERY.O	0.024	74.000	19.000
NAI.O	0.021	10.397	20.000
QERY.I	0.021	74.000	21.000
RELA.O	0.018	29.950	22.000
UTO.O	0.016	87.953	23.000
BIR.O	0.005	126.532	24.000
SDL.O	0.003	0.0	25.000
PLM.O	0.003	0.0	26.000

EXHIBIT B-2: PROGRAM OUTPUTS

(Continued)

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*******                                       *******
*******   TABLE 3:  PROCESSOR SUMMARY STATISTICS   *******
*******                                       *******
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PROCESSOR	EXPECTED DELAY (MIN.)	EXPECTED QUEUE LENGTH	TRAFFIC RATE (MSG/HR.)	UTILIZATION	RANK
DISCOM	0.001	0.001	97.954	0.001	1.000
BN3.5	0.001	0.000	9.001	0.000	2.000
BN3.3	0.001	0.000	8.997	0.000	3.000
BN2.3	0.001	0.000	21.969	0.000	4.000
BN3.1	0.001	0.000	10.997	0.000	5.000
BN3.2	0.001	0.000	10.997	0.000	6.000
BN2.2	0.001	0.000	23.969	0.000	7.000
BN3.4	0.001	0.000	10.000	0.000	8.000
DIV ARTY	0.001	0.001	156.929	0.001	9.000
BN2.5	0.001	0.000	23.063	0.000	10.000
OPS EL	0.001	0.001	211.560	0.002	11.000
BN2.1	0.001	0.000	30.288	0.000	12.000
CAV SQN	0.000	0.001	247.000	0.002	13.000
ENG BN	0.000	0.000	86.003	0.001	14.000
AVN BN	0.000	0.000	84.890	0.001	15.000
BN2.4	0.000	0.000	40.009	0.000	16.000
BDE1	0.000	0.009	485.933	0.003	17.000
TACFIRE	0.000	0.000	40.001	0.000	18.000
BN1.3	0.000	0.000	33.985	0.000	19.000
BN1.1	0.000	0.000	35.985	0.000	20.000
BN1.2	0.000	0.000	35.985	0.000	21.000
BN1.5	0.000	0.000	29.014	0.000	22.000
NATO	0.000	0.000	30.960	0.000	23.000
ADA BN	0.000	0.000	39.992	0.000	24.000
BN1.4	0.000	0.000	31.025	0.000	25.000
INTEL EL	0.000	0.004	228.046	0.001	26.000
ADJ DIVS	0.000	0.001	47.993	0.000	27.000
CEWI BN	0.000	0.000	101.938	0.001	28.[illegible]
TAC CP	0.000	0.006	330.771	0.001	29.[illegible]
BDE3	0.000	0.003	172.963	0.001	[illegible]
BDE2	0.000	0.007	355.416	0.001	[illegible]
FEP	0.000	0.000	2718.255	0.000	[illegible]

EXHIBIT B-2: PROGRAM OUTPUTS

(Concluded)

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*******                                           *******
*******   TABLE 4:  CHANNEL SUMMARY STATISTICS    *******
*******                                           *******
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CHANNEL	EXPECTED DELAY (MIN.)	EXPECTED QUEUE LENGTH	TRAFFIC RATE (MSG/HR.)	UTILIZATION	RANK
CAV SQN	0.204	0.418	247.000	0.420	1.000
BDE1 FM	0.202	0.256	165.994	0.304	2.000
BDE2 FM	0.176	0.174	139.299	0.236	3.000
BDE3 FM	0.174	0.055	49.992	0.090	4.000
NATO FM	0.149	0.029	30.960	0.048	5.000
MICRO	0.004	0.646	2000.715	0.005	6.000
CABLE	0.003	0.022	439.606	0.006	7.000

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*******   TABLE 5:  DCC COMPONENT SUMMARY STATISTICS   *******
*******                                                *******
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DCC COMPONENT	EXPECTED DELAY (MIN.)	EXPECTED QUEUE LENGTH	TRAFFIC RATE (MSG/HR.)	UTILIZATION
DBP	0.000	0.000	2718.255	0.001
MD CONTRO	0.003	0.065	2718.255	0.116
DD CONTRO	0.001	0.015	2718.255	0.029

APPENDIX C: GLOSSARY OF ACRONYMS

A & P	-	Analysis & Production
ACK	-	Acknowledgement
ADA BN	-	Air Defense Artillery Battalion
ADP	-	Automated Data Processing
ARM CAV	-	Armored Calvary
ARQ	-	Automatic Retransmission on Request
AVN BN	-	Aviation Battalion
BDE	-	Brigade
BIR	-	Battlefield Information Report
BPS	-	Bits Per Second
BN	-	Battalion
CAV	-	Cavalry
CCC	-	Computer Control Console
CDR	-	Commander
CEWI	-	Combat Electronic Warfare Intelligence
CIM	-	Communications Interface Module
CMS	-	Communications Management System
COMSEC	-	Communications Security
CONOPS	-	Continuity of Operations
CP	-	Command Post
CPU	-	Central Processing Unit
D/K/P	-	Display/Keyboard/Printer
D/L	-	Distribution List
DAME	-	Division Airspace Management Element
DB	-	Double Blocking

APPENDIX C: GLOSSARY OF ACRONYMS

(continued)

DBMS	-	Data Base Management System
DBP	-	Data Base Processor
DCC	-	Division Computer Center
DDA	-	Design/Decision Aid
DIOM	-	Data Input/Output Module
DISCOM	-	Division Support Command
DIV ARTY	-	Division Artillery
DTOC	-	Division Tactical Operations Center
DTOS	-	Division Tactical Operations System
E/V	-	Edit and Validation
EDC	-	Error Detection and Correction
EMI	-	Electromagnetic Interference
ENGR BN	-	Engineering Battalion
ENQ	-	Enquiry
ENSIT	-	Enemy Situation
EOB	-	Enemy Order of Battle
ESD	-	Enemy Situation Data
EW	-	Electronic Warfare
FDC	-	Fire Detection Center
FDX	-	Full Duplex
FEC	-	Forward Error Correction
FEP	-	Front End Processor
FM	-	Frequency Modulation
FMS	-	File Management System

APPENDIX C: GLOSSARY OF ACRONYMS
(continued)

FRENSIT	-	Friendly Situation
FSE	-	Fire Support Element
FSK	-	Frequency Shift Keying
HDX	-	Half Duplex
I/O	-	Input/Output
ICM	-	Intelligence Collection Management
IDS	-	Interactive Display System
IMR	-	Incoming Message Retrieval
INTEL	-	Intelligence
IOI	-	Input/Output Interface
IOU	-	Input/Output Unit
KBPS	-	Kilobits Per Second
MCMU	-	Mass Core Memory Unit
MLM	-	Memory Loading Module
MLU	-	Memory Load Unit
MSG	-	Message
NAI	-	Named Area of Interest
NAK	-	Non-Acknowledgement
NATO	-	North Atlantic Treaty Organization
OPS	-	Operations
OS	-	Operating System
PLM	-	Preloaded Message
PM	-	Project Manager
RMC	-	Retained Message Copy

APPENDIX C: GLOSSARY OF ACRONYMS
(concluded)

SB	-	Single Blocking
SDL	-	Standard Distribution Lists
SIU	-	System Interface Unit
SOP	-	Standard Operating Procedure
SQN	-	Squadron
SRI	-	Standing Request for Information
SWF	-	Staff Working File
SYSCON	-	System Controller
TAC CP	-	Tactical Command Post
TACFIRE	-	Tactical Fire Direction System
TB	-	Triple Blocking
TCS	-	Tactical Computer System
TCT	-	Tactical Computer Terminal
TCU	-	Terminal Control Unit
TDC	-	Time Dispersed Coding
TER	-	Terrain File
TOC	-	Tactical Operations Center
TOS	-	Tactical Operations System
UTD	-	Unit Tactical Disposition
UTO	-	Unit Task Organization
XMSN	-	Transmission